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VOL. 6 NO. 4 NOVEMBER, 1919

PROCEEDINGS 39TH YEAR

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

PUBLISHED IN JANUARY, MARCH, MAY, JULY, SEPTEMBER AND NOVEMBER

BY THE

AMERICAN WATER WORKS ASSOCIATION

AT MOUNT ROYAL AND GUILFORD AVENUES, BALTIMORE, MD.

SECRETARY'S OFFICE, 153 WEST 71ST ST., NEW YORK
EDITOR'S OFFICE, 100 LORRAINE AVENUE, UPPER MONTCLAIR, N. J.

Subscription price, $5.00 per annum

Entered as second class matter April 10, 1914, at the Post Office at Baltimore, Md., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 6, 1918

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JOURNAL

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OF THE

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VOL. 6 NOVEMBER, 1919 No. 4

COMMENTS

GROWTH OF THE ASSOCIATION

Every member of the American Water Works Association will be glad to have the following news from the chairman of the Membership Committee:

> I have received during the past few days, more than fifty applications for membership in the Association. I am very much pleased with the very evident interest in the Association and the great interest manifested in our JOURNALS. These applications have come from public utility commissions, state boards of health, high-grade consulting engineers, water-works superintendents, and so forth, and I believe that the larger number of these men will remain as permanent members.

This gratifying evidence of the interest aroused by the efforts of the Executive Committee to make the Association of the maximum value to all interested in supplying water to our cities also imposes an obligation upon the members of the organization. We are asking men to join our ranks because we believe that membership in this body will be useful to them; we are not asking them to join merely as contributors to a small annual income used for purposes which will not be helpful to them. Every member of the organization, by the fact of his membership, assumes a certain measure of responsibility for its work. He is not a mere stockholder in a company in which he

invests in the hope of monetary profit alone, but he is a member of an association in which all are equal partners in striving to accomplish one thing, supplying wholesome water at minimum expense.

The Association will continue to grow in influence and numbers so long as all members of it will coöperate in making it of the greatest service to the greatest number. The officers of the Association will be able to do better work if the members write freely to them about those things they will be glad to have done and their criticisms of the things that have been done. In matters of general policy members should write to the executive committeemen from the districts where they live, in order that they may know the members' views and, if they consider it desirable, secure the opinions of other members in these districts. Membership subjects should be taken up with the chairman of the Membership Committee, whose active work is proving so successful. Matters relating to the JOURNAL should be taken up with the editor, who keeps the Publication Committee informed of all matters relating to the Association's publication. The addresses of these officers are given in the list of members and will be printed hereafter on the back of the flyleaf of each JOURNAL. They wish most earnestly to receive suggestions from the members about any subject relating to water works design, construction and management which interests them.

There is at the present time one subject to which each member should give careful thought, for without expressions of opinion from many members the Executive Committee cannot discharge its duties with the full knowledge of the general opinion of the Association as a whole which it must have to act most wisely. The close of the war has left us with so many new problems to face that in everything we do it is necessary to take count of stock of what we have, what is desired, and what we can do with our resources. The Association is obliged to answer these questions within a year or so. Its future depends upon answering them wisely. The most helpful information the Executive Committee can receive during the next few months will be statements from the members concerning just what they feel they should receive for their annual dues of five dollars. A large number of societies are now asking this question, for the greatly increased costs of conducting work of any kind have brought many of them, large as well as small, to a realization that they must count every penny and cut off every expense which does not produce results really useful to the members. The American Water Works

Association is not alone in facing this situation, for it has presented serious problems to great organizations like the American Society of Civil Engineers.

CARLETON E. DAVIS.

THE OPERATION OF SMALL PURIFICATION PLANTS

The consulting engineer who designs a water purification plant for the average small city should have a cheerful disposition and an optimistic outlook. Without these attributes he is likely to feel disappointed, or even bitter, at the treatment which this child of his brain will receive at the hands of the guardians to whose care its management is assigned. In Illinois we are now giving serious attention to the operation of the plants for treating water and sewage, because it leaves much to be desired in some cases, and there is evident need of arousing an interest among public officials generally in the desirability of competent control of such works. There is an unfortunate inclination to look upon them like tractors or trucks, as something which will work all right if the proper lubricant is occasionally squirted in the oil cups that can be reached easily.

We are beginning to encourage a policy of doing more than merely relying on the treatment of water as a safeguard against the pollution of municipal supplies. Purification plants owned by small cities cannot have the staff of trained experts to supervise their operation which a large plant possesses. There is a greater hazard or risk inevitable in the small plants and provision ought to be made against the extra hazard if it is practicable to do so. Life is just as valuable to the resident in a place of five thousand as to the resident in a metropolis, and therefore we should try to place about each of them sanitary safeguards of equal effectiveness. So in Illinois we are now attempting to persuade municipalities installing new water supplies to acquire control over the tributary watershed where this is practicable, and in all cases to maintain a watershed patrol which will reveal promptly any source of dangerous contamination of the water.

As a further step in improving the management of small plants for treating water and sewage, the State Department of Public Health is encouraging the practice of retaining the services of a consulting engineer on an annual-fee basis to supervise the operation of such works. The service needed can be rendered for a very small fee in most cases, and the plan is not only a great benefit to the munici-

pality having such advice but is also of value to the engineer in giving him an opportunity to observe the operation of the plants he designs. Under conditions heretofore prevailing the engineer rarely sees the plants he designs after their completion and preliminary test runs, and even in the case of such runs he usually contributes his time and pays his expenses for the visit. In this respect the small works offer a great contrast to the large plants, yet it is the small works which need the supervision of their designer most. We are so certain of the benefits that will follow from the adoption of the policy outlined that we expect to take over before long the systematic control of a small string of works for treating water and sewage, in order to show by practical demonstration what can be accomplished by expert supervision and thus establish the value of expert advice to municipalities owning small plants of this nature.

PAUL HANSEN.

IS MORE MECHANICAL ENGINEERING SKILL NEEDED BY THE WATERWORKS FRATERNITY?

In a recent conversation with a mechanical engineer a remark was made that many of the mechanical appliances used by water works men were crude, from a mechanical view point, and the opinion was voiced that the mechanical engineer could do much to improve such appliances. The writer is inclined to assent, in part at least, to the correctness of this view and is interested in learning what are the opinions of his fellow water works managers.

Water supply has been considered a civil engineer's specialty, and the mechanical engineer is generally only brought in as an expert for some pumping problem. It is seldom that adequate provision is made for a mechanical engineering force, even in our largest systems, although there are many important mechanical engineering problems to be handled in both maintenance and construction work. The water works field does not attract mechanical engineers, as they consider that the opportunities it offers are too limited to be inviting. The civil engineer is inclined to think he can do the mechanical part in a reasonably efficient manner, and does not willingly call on his mechanical brother. It would be helpful if more mechanical engineering skill were devoted to the water supply work, and we should all encourage and welcome the mechanical men to join in advancing the water supply art.

An illustration of how helpful to the civil engineer the mechanical mind can be in securing an adequate machine to accomplish a desired end is well set forth in the work of the Board of Water Supply of New York. That organization always has had its mechanical section, and our reliance today in New York City on the automatic closing of a valve a hundred feet or more below the surface, if a break occurs in the piping or appurtenances at the surface, is due to an idea promulgated by a civil engineer and developed into a highly efficient and dependable machine by the mechanical engineers. This is but one of many instances where the mechanical engineers' aid has been successfully applied to the Catskill water system problems. Just how the mechanical engineers can be enlisted for our work is a question more easily asked than answered. The writer believes that our water works specialty manufacturers could use to advantage more mechanical engineering skill in the development of their appliances, and that a more liberal spirit among water works men to try equipment that embodies new ideas would be helpful.

W. W. Brush.

STANDARDIZING UNDERSIZE FIRE COUPLINGS

It is most gratifying to be able to report to the Association the successful standardization of a considerable number of undersized fire couplings, for this is a long step forward in the work which the Association authorized in 1905 and has not always progressed as rapidly as those who have it at heart would welcome. Trenton, N.J., employs the National Standard couplings. Lambertville and High Bridge, N. J., and New Hope, Pa., are suburbs which rely upon Trenton for help in case a fire gets away from the local departments. At High Bridge the threads on the fittings had an outside diameter of 3 inches and there are eight threads to the inch, while at Lambertville and New Hope the outside diameter was $3\frac{1}{16}$ inches with eight threads to the inch. In these towns there were 191 pairs of hose couplings, 41 play pipes, 18 hydrant hose gates, 16 chemical and pump connections, 113 hydrant caps, 219 hydrant nozzles, 2 siameses, 5 double males, 2 suction reducers and 2 steamer connections to be standardized. The town authorities requested this work to be done and it was accomplished in two and one-half days by three men, with a helper during part of the time to handle the hose.

The results show that two experienced men can standardize

threads of this kind on 125 pairs of hose couplings or on 75 two-outlet street hydrants in a day. A few hydrant nipples and undersized male couplings were cracked while being expanded, either because the shells were very thin or the composition of the metal was inferior in character. The results of this first field test of such work encourage the belief that such standardization is practicable and satisfactory in the case of undersized fittings down to an outside diameter of $2\frac{31}{32}$ inch. It is now desirable to obtain authority to standardize oversized fittings with outside diameters of $3\frac{5}{64}$ inches or $3\frac{3}{32}$ inches. If these field tests prove as satisfactory as those made in the suburbs of Trenton the standardization of fittings in municipalities generally can be undertaken with the certainty of a successful outcome.

F. M. GRISWOLD.

A STANDARD FORM OF CONSTRUCTION CONTRACT

Members of the Association who attended the St. Louis convention will recall that the president of the American Society of Engineering Contractors, Albert P. Greensfelder, made an informal address on the subject of a standard form of contract for construction, which led to the appointment of a committee of the American Water Works Association to investigate the subject. The informal address referred to was printed in the JOURNAL of December, 1918, and the report of the committee appeared in the number for September, 1919. The report was sent to Mr. Greensfelder, as the original mover of the investigation, and the following comment on it has been received from him:

> We cannot concur that it is wise to have lawyers continue to defend bad practices. We believe that it is up to progressive associations to present good practices. Contracts that are equitable and fair to both parties tend to reduce legal controversies. We do not take issue so much with specifications drawn by older and more experienced members of your Association, but rather with those presented by inexperienced men. It would surely seem to be the province of an Association as enterprising and progressive as yours to protect the interests of water-works owners by drafting an equitable form of contract. Enforcing the use of such a contract would be unnecessary, as custom will gradually bring it into current use, as the forms adopted by the American Institute of Architects have demonstrated.

The history of standard forms of contract in other fields than that of water works has been a record of very slow progress even when

their use today is quite general. The most signal case is that of the forms of the American Institute of Architects; practically the same arguments concerning such forms were advanced by architects years ago as will be found in the report of our own committee, yet today very few architects use any other forms. No work done by that Institute has ever been more helpful to all concerned in the building industry than the standardization of contract forms, yet when the work was begun very few indeed realized its importance. It should be kept in mind that standardization of contract forms rather than of specifications is under discussion.

The writer happens to have been associated in some of the standardization of specifications which has been quite generally adopted by civil engineers, and also in the standardization of contract forms for road work. The two kinds of standardization are quite unlike in the amount of detail investigation involved, and the committee which attempts to propose standard contract forms will find a long task ahead of it, much longer than in the standardization of specifications. It has been the writer's opinion that the subject was one for the American Society of Civil Engineers rather than for an association devoting itself to all phases of the work of one class of public utilities, like our own. Nevertheless if this Association can find men who are willing to serve on a committee which will have an enormous amount of detail work to perform, it can accomplish a result which will add distinction to its name and increase its prestige as a national technical organization which gets desirable things done.

There can be no question that many forms of contract offered to contractors today are unfair, and that the contractor agrees to them only because he is confident that the unfairness is intended to keep away incompetent men and not to be used as a club on those who are competent. The committee states this in more diplomatic language in its report, but the thought seems to be the same in both forms of expression. This is not good public policy, for in the long run subterfuges make more trouble than they do good. Every engineer knows that a great deal of work is going on today under forms of contract which are a reflection on his fairness, if literally interpreted. Mr. Greensfelder is right in contending that it is time for the engineer to insist on fairness in contract forms, even if it is necesary for the lawyer to give real thought and study to methods of achieving equity in contract provisions, along with proper protection for his client. In other words, the lawyer has shouldered the engineer and manager

off this particular field of construction activities long enough, he has succeeded in complicating it to such an extent that some contracts ought not to be signed by any contractor without a legal guarantee that they do not mean what they say, and the time has certainly come, with all the readjustment of our country's business relations, for the drafting of contract forms for engineering construction which are equitable to all parties and perfectly clear in their meaning when the words in them are employed with every-day significance.

JOHN M. GOODELL.

KEEPING THE FIRST ARMY SUPPLIED WITH WATER[1]

By. Lieut.-Col. F. W. Scheidenhelm

Ammunition, water, food—all are essential to keep an army in fighting trim. Ammunition is essential for fighting, water and food are essential for *efficient* fighting and for life. The individual soldier or animal feels the lack first of water, then of food. Depending upon the availability of other means of transportation, water was at times given priority over ammunition as regards transportation over the narrow gauge railways at the front.

The problem of water supply at the front is simple in detail. The quantities of water handled at any one place are small. The difficulties are due rather to the extent of territory to be covered and the speed necessary in making supplies available.

Aside from the necessity of having a general familiarity with matters of hydraulics, of having the water supply point of view, so to speak, the engineering work involved is really of elementary character. No reference books were necessary except, perhaps, a table of friction losses in pipe. Executive and organization work, on the other hand, stood out as of prime importance. In fact the water supply work at the front might well be characterized as "rough and ready,"—*rough* because it had to be *ready* for the arrival of certain troops or for some other contingency.

The water supply along the American front was the responsibility of the Water Supply Service of the field armies. The present discussion deals with the work of the Water Supply Service of the American First Army. Its responsibility covered water for men, for animals, for railways, both standard and narrow gauge, and for hospitals, including field and evacuation, but not base, hospitals. Under campaign conditions the Engineer Department of the U. S. Army is responsible for water supply. Under pre-war regulations responsibility for quantity only was contemplated, but under the

[1] Revised notes of an informal address at the Buffalo convention, June 12, 1919. The author was in charge of the water supply service of the First Army, A. E. F.

regulations adopted for the American Expeditionary Forces, the responsibility of the Engineer Department, of which the Water Supply Service formed a part, was extended to include quality also. The responsibility for quality, however, extended only to and including "water points," as will be explained in more detail.

Prior to the recent war such a thing as a Water Supply Service was unknown. It was the great densities of troop concentration that brought into the forefront the need for such a Service. The French in 1915, and soon thereafter the British, were the forerunners in establishing special services for this purpose. Profiting by their experience the American Expeditionary Force prepared in its early stages to set up its own Water Supply Service. What troop density means may perhaps be better appreciated after considering that a common density prior to a great attack involved 100,000 men with, say, 35,000 animals, all crowded into an area having a front of three miles and a depth not exceeding seven miles.

The principal areas involved in the American concentration prior to the St. Mihiel drive supported a pre-war population of about 25,000 civilians. These same areas during the concentration supported a military population of about 600,000 men, together with nearly 200,000 animals. The pre-war water supply was none too ample for parts of the region. In fact, those very parts where troops were to be crowded most densely had but little potable water, especially during the latter part of the summer season. The supply of drinking water in the region, therefore, had to be increased to something like twenty-five times its earlier capacity. Even the four years of military occupation of the area preceding the St. Mihiel drive had resulted in increasing the supply to only about six times the pre-war supply.

The Water Supply Service of the American Expeditionary Forces centered around the 26th Engineers, a regiment especially organized, largely by means of volunteers, for water supply work. A number of its officers were detailed from time to time for headquarters and other staff work. Thus Major (subsequently Colonel) F. F. Longley, a member of this Association, was sent to France in advance of the water supply troops and remained the principal officer of this Service at the headquarters of the Chief Engineer, A. E. F.

The need for water supply troops in France resulted in scattering the several companies of the 26th Engineers over various parts of the area of the Services of Supply, beginning as early as November,

1917. It was not until May, 1918, that the first of the water supply troops reached the front north of Toul; but even so, they were ahead of any American forces operating independently. As the American First Army got under way in its St. Mihiel and Argonne-Meuse operations, a maximum of four companies of the regiment were gathered into that Army, and these, together with a large number of attached troops, formed the Water Supply Service of the First Army.

These Water Supply troops were army troops, that is, army troops as distinguished from the troops of divisions or of army corps. Their work was one of service for the divisions, the corps troops, and the other army troops; in fact, of service for the army as a whole. The head of the service was known as the Water Supply Officer, Army, reporting to the Chief Engineer, Army. This was the position held by the speaker, who in due course became commanding officer of the 26th Engineers in the field.

Water along the front is essentially an *area* matter, that is, water supply installations are ordinarily "tied to the ground," so to speak. Therefore the army area was divided into sectors and these in turn into districts. So far as practicable the districts corresponded to the tactical areas of the corps (composed of a group of divisions). As the front advanced, the districts naturally became extended in depth and the difficulties of covering the territory increased correspondingly.

The *modus operandi* was essentially one of wholesaling water to the tactical organizations, that is, to companies of infantry, batteries of artillery, etc. These organizations called for their water in wholesale at the "water points," that is, points where water was made available to all comers. Beyond the water points the organizations themselves were responsible for the transportation of the water to their own troops, by means of water carts, hand containers, and what not. In general, the water points were spaced so that the maximum travel involved on the part of organizations to the nearest water point would not exceed $1\frac{1}{2}$ miles. Frequently they were spaced more closely.

Likewise, beyond the water point, the responsibility for quality changed. That is, once the water had been taken from the water point, any needed disinfection treatment was incumbent on the Medical Department, through the medical officers attached to the infantry, artillery, etc.

Quite in contrast with the per capita supply of the cantonments in the United States, 55 gallons per man per day, the aim at the front was to provide an average of 2 gallons per man per day. Under conditions of stress, as for instance during the first two days of the St. Mihiel attack, the best that could be offered in certain areas was a little less than 1 gallon per man per day. Animals needed from 8 to 10 gallons per day. Fortunately, in few cases did the animals compete with the troops for water supplies. As far as possible animals were watered from streams and lakes.

The water problems of the St. Mihiel operation exceeded in difficulty those of the Argonne-Meuse operation. Regarding the former, Brigadier General Morrow, as Chief Engineer, First Army, made the statement that of the engineering problems, those of communications and water supply were of primary and parallel importance. The area, as has been stated, is poorly watered, especially during the dry season of the year in which the operation took place. The first consideration of the Water Supply Service was, therefore, to obtain really wet water, and the second, to make that water as pure as practicable.

In the Argonne-Meuse operation, on the other hand, the local water suppplies were greater in number and quantity. There the difficulties lay rather in the necessity for speed in preparing for the initial concentration and in meeting the kaleidoscopic changes resulting from tactical successes.

The functions of the water supply troops included the location and development of sources of supply, such as springs, streams, lakes, dug wells, and bore-holes; the construction of the necessary pumping stations, pipe lines, reservoirs, and water point facilities; the operation of water points, including pumping stations; and the quality control of water. In the operation of pumping stations, the assistance of electrical-mechanical troops was had in the early stages of the campaign, but the tendency later on was to make the Water Supply Service more and more self-dependent along this as well as other lines.

The organization of the Water Supply Service of the First Army, for the purpose of carrying out the above functions, is shown in figure 1. The headquarters of the service were framed around the regimental headquarters of the 26th Engineers and generally were located at First Army Headquarters, along with those of the Chief Engineer, Army. The headquarters included the heads of all de-

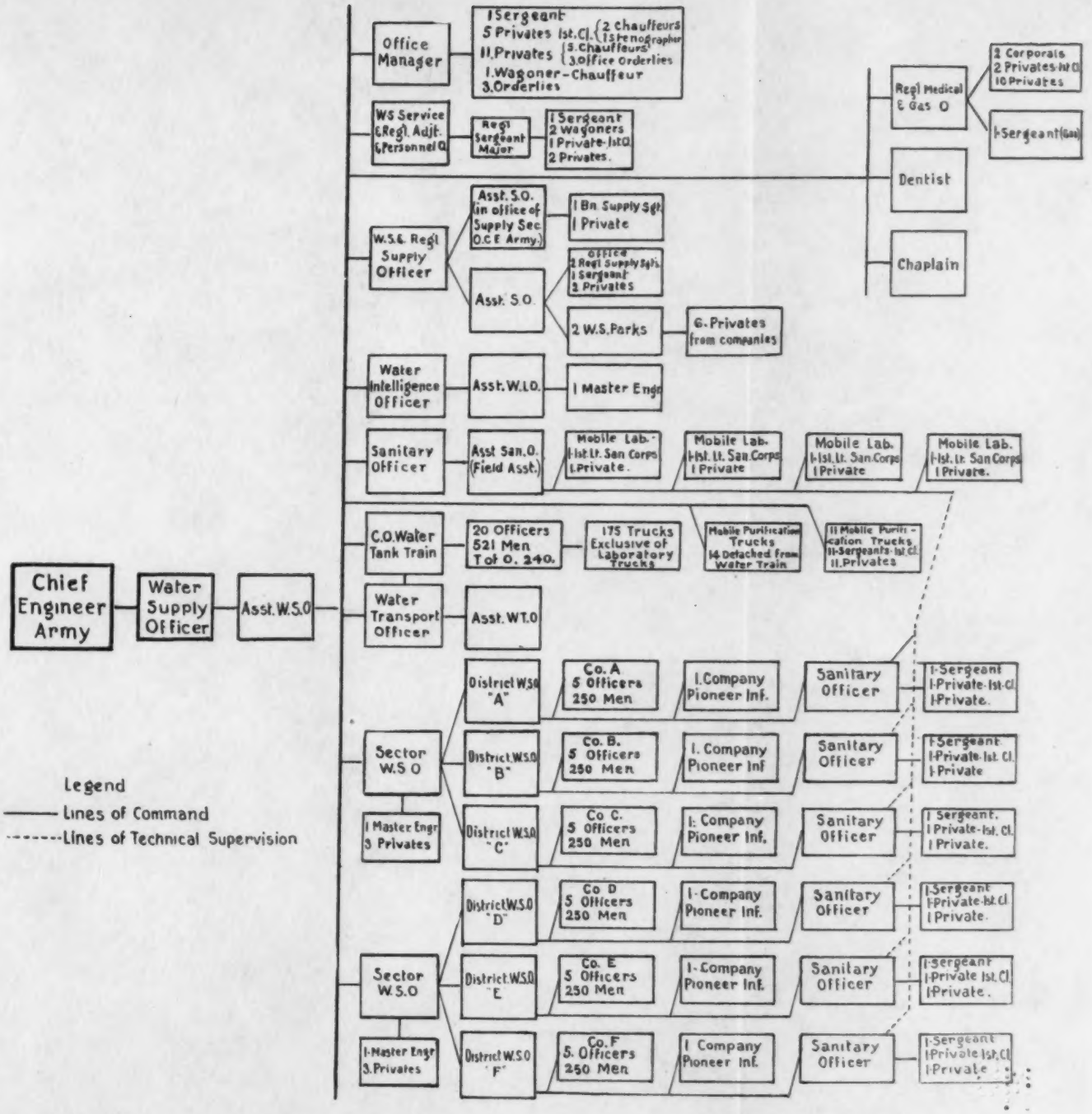

Chief Engineer Army
Water Supply Officer
Asst. W.S.O
Legend
——— Lines of Command
------Lines of Technical Supervision
Office Manager
1 Sergeant
5 Privates 1st. Cl. (2 Chauffeurs, 1 Stenographer)
11 Privates (5 Chauffeurs, 3 Office Orderlies)
1 Wagoner-Chauffeur
3 Orderlies
W.S. Service & Regl. Adjt. & Personnel O.
Regl. Sergeant Major
1 Sergeant
2 Wagoners
1 Private-1st Cl.
2 Privates.
Regl Medical & Gas O
2 Corporals
2 Privates 1st Cl.
10 Privates
1 Sergeant (Gas)
Dentist
Chaplain
W.S.& Regl. Supply Officer
Asst. S.O. (in office of Supply Sec. O.C.E Army.)
1 Bn. Supply Sgt.
1 Private
Asst. S.O.
Office
2 Regl. Supply Sgts.
1 Sergeant
2 Privates
2 W.S. Parks
6 Privates from companies
Water Intelligence Officer
Asst. W.I.O.
1 Master Engr.
Sanitary Officer
Asst San. O. (Field Asst.)
Mobile Lab. 1 1st Lt. San Corps 1 Private.
Mobile Lab. 1 1st Lt. San Corps 1 Private
Mobile Lab. 1 1st Lt. San Corps 1 Private
Mobile Lab. 1 1st Lt. San Corps 1 Private.
C.O. Water Tank Train
20 Officers 521 Men Tot O. 240.
175 Trucks Exclusive of Laboratory Trucks
Mobile Purification Trucks 14 Detached from Water Train
11 Mobile Purification Trucks 11 Sergeants 1st Cl. 11 Privates
Water Transport Officer
Asst. W.T.O
Sector W.S.O
1 Master Engr 3 Privates
District W.S.O "A"
Co. A 5 Officers 250 Men
1 Company Pioneer Inf.
Sanitary Officer
1 Sergeant 1 Private-1st Cl. 1 Private.
District W.S.O "B"
Co. B. 5 Officers 250 Men
1 Company Pioneer Inf
Sanitary Officer
1 Sergeant 1 Private-1st Cl. 1 Private
District W.S.O "C"
Co C. 5 Officers 250 Men
1 Company Pioneer Inf.
Sanitary Officer
1 Sergeant. 1 Private-1st Cl. 1 Private.
Sector W.S.O
1 Master Engr 3 Privates
District W.S.O "D"
Co D 5 Officers 250 Men
1 Company Pioneer Inf.
Sanitary Officer
1 Sergeant 1 Private-1st Cl. 1 Private.
District W.S.O "E"
Co. E 5 Officers 250 Men
1 Company Pioneer Inf.
Sanitary Officer
1 Sergeant 1 Private 1st Cl. 1 Private.
District W.S.O "F"
Co. F 5 Officers 250 Men
1 Company Pioneer Inf.
Sanitary Officer
1 Sergeant 1 Private 1st Cl. 1 Private

FIG. 1. ORGANIZATION CHART OF THE WATER SUPPLY SERVICE OF AN ARMY, A. E. F.

partments, excepting only the Sector Water Supply Officers who were in direct field charge. Of purely administrative nature were the positions of Office Manager, Adjutant and Personnel Officer. Among the administrative functions of headquarters was that of maintaining liaison, not merely with the other services and branches

FIG. 2. THE LYSTER BAG

Much of the water "wholesaled" by the Water Supply Service was "retailed" through such bags.

of the American First Army, but also with the French Eighth Army on the right and the French Second Army, originally on the left of the American First Army and subsequently, in the Argonne-Meuse operation, entirely displaced by the American First Army.

FIG. 3. A WATER POINT ALONG THE MONTFAUCON-AVOCOURT ROAD

Here there was limited storage, with facilities for filling water carts and watering animals

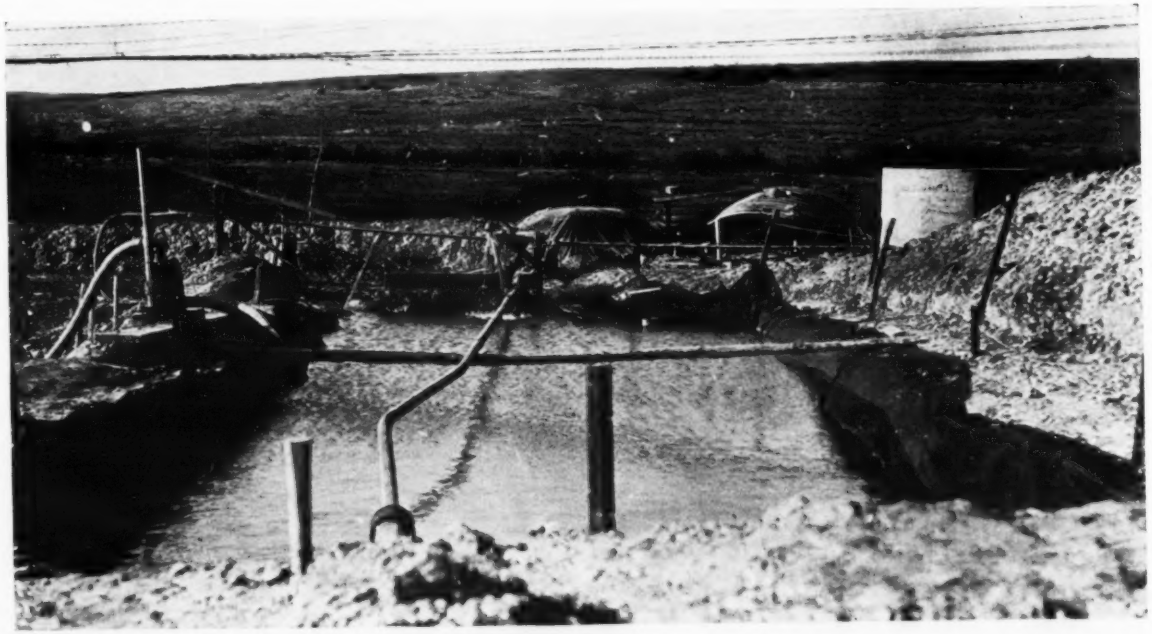


FIG. 4. AN EMERGENCY RESERVOIR WITH CANVAS LINING NEAR MONTFAUCON

This reservoir held 7500 gallons and was filled from a spring by gravity. Many basins of this type were supplied by means of water tank trains (motor).

FIG. 5. MOTOR TANK TRUCKS AT IVOIRY (ARGONNE MEUSE)
A captured German concrete reservoir of 17,000 gallons capacity was utilized here

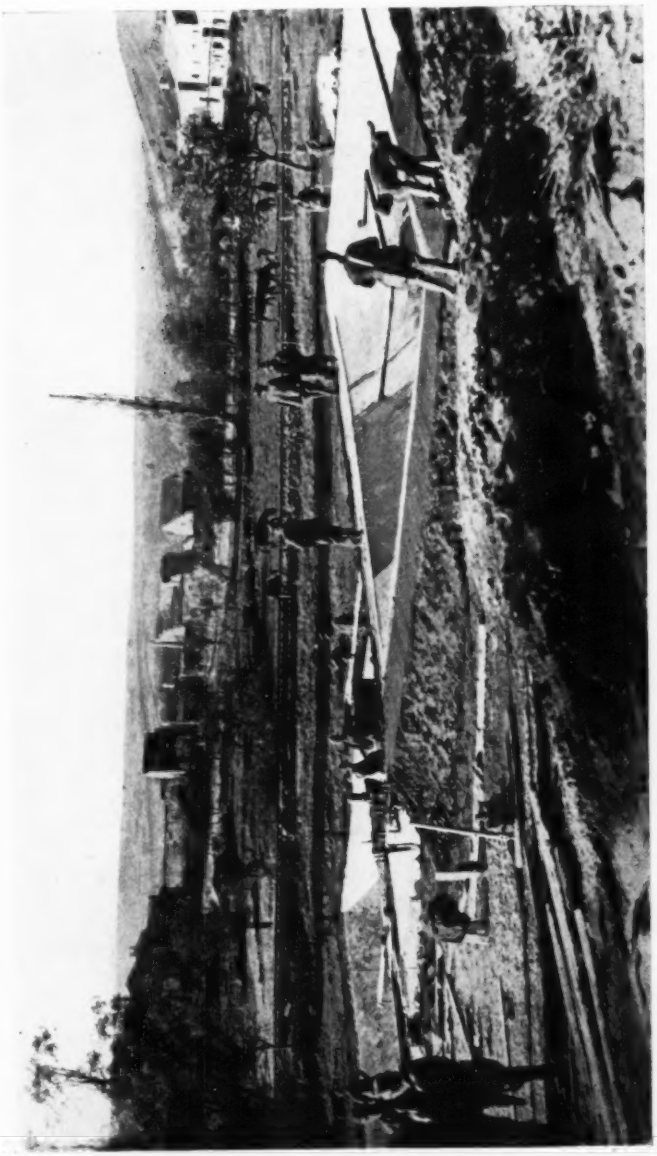


FIG. 6. WATER PURIFICATION PLANT AT EUVEZIN (ST. MIHIEL AREA)
This was one of the most ambitious works at the front of the Water Supply Service

The Reconnaissance or Water Intelligence Department was important in spite of the fact that it was not large. It was most ably headed by Captain Charles H. Lee, 26th Engineers, a member of this Association. It had to do with the obtaining, and making known to proper quarters, of information regarding water supply and water points within our own lines, and also the water supply to be expected or probably most practicable of development once the confronting enemy territory should be taken. Hydrological and geological features received study. The results of the Water Intelligence work were expressed in bulletins and maps. In the latter, especially, some records of high speed production were attained. Thus it became possible to compile during an evening all the information available up to that time: the necessary tracing, lithographing and printing were done during the night; and the maps were ready for distribution early on the following day. This included a 120 kilometer round trip by motor cycle to the lithographing plant.

The Construction Department was naturally of exceeding importance. The Sector Water Supply Officers were in charge of all water supply activities within their sectors, but most of their effort, and that of the troops under them, was devoted to construction. The territorial Districts, as indicated in figure I, were generally in charge of the commanding officer of one of the companies of the 26th Engineers, who had under him his own company plus a company of Pioneer Infantry. Aside from the 26th Engineers the troops which contributed largely to the water supply construction work, under the First Army Water Supply Service, were the 37th Engineers, the 27th Engineers, and 59th Pioneer Infantry.

But construction work could not be carried on without materiel and here frequently was the rub. A supply officer of the Service was overheard to say: "The only things which the Water Supply Service lacks are personnel, materiel, and transportation." The remark was entirely pardonable, for the difficulties were tremendous. The regimental equipment, specified and shipped with great care from the United States, never reached the regiment. It was only the invoices that came to the regiment in France. In spite of the difficulties, however, the water supply "parks" and "dumps," the larger and smaller depots of materiel, were gradually stocked up by the Supply Department of the Service and it became possible to operate at reasonable efficiency. Much materiel was obtained from French sources.

Under the circumstances standardization was necessarily an ideal rather than a reality. The array of pumps was indeed a motley one. The following figures will give an idea of the quantities involved:

For the two larger operations for the First Army, the Water Supply Service received a total of 300 gasoline engine operated pumps and 400 hand pumps. During the months of September and October, 1918, the following quantities of pipe were received from the rear: 1-inch, 82,000 feet; 2-inch, 86,500 feet; 4-inch, 146,000 feet. In the interest of simplification the above three mentioned sizes of pipe were made standard for army use. For the same reason crosses were eliminated from the fittings and also reducers. The latter fact made it proper to say:

> The reducer is dead,
> Long live the bushing.

Where water was lacking locally it was necessary to set up artificial water points. These were supplied by transporting water from other sources of supply. Hence there resulted the Department of Transportation of Water.

At the time of the St. Mihiel operation, for which the need for transportation of water was greatest, the authorized Water Tank Trains (Motor) had not arrived from the States. It, therefore, became necessary to organize Provisional Water Tank Trains, totaling about 80 trucks and 260 men. Among the latter was a motor truck company detailed from the 23d Engineers (the road regiment). In the case of the First Provisional Water Tank Train, cargo tracks were equipped for water carrying by means of closed galvanized iron tanks of about 500 gallons capacity, French wine casks, etc. Its total capacity was about 39,000 gallons. The Second Provisional Water Tank Train was made up by converting, to water hauling use, 34 three-compartment, 750-gallon, gasoline carrying trucks. The latter proved to be even better for the purpose than did the specially designed water tank trucks which arrived later on.

After the beginning of the Argonne-Meuse campaign the 301st and 302d Water Tank Trains (Motor) reached France with part of their equipment and in due course the former came to the First Army front. Its personnel of about 500 was utilized largely in manning the trucks of the Provisional Water Tank Trains.

In addition to transportation by motor tank trucks, water was

transported by light railway tank cars. Of these approximately 50 were put into use within the First Army area. The cars were entirely of steel and of 2,000-gallon capacity. They were handled by the Light Railway Service under the direction of the Water Supply Service and proved to be a most useful asset in conveying water not merely for men but also for animals. Especially useful were they in reaching artillery positions in wooded areas into which there penetrated no good highways.

The Department last to be mentioned, but by no means least important, is that of Quality Control, having in charge the quality phases of water supply. Its personnel was drawn from both the Engineer Department and the Sanitary Corps of the Medical Department. The greater number of the officers concerned were sanitary or public health engineers. A number of them, including Captain H. P. Letton, in charge of the quality control work for the First Army during the latter part of the campaign, are members of this Association.

It was the policy to assume that all water found in the field was bad unless proven to be otherwise. Emphasis was, therefore, laid upon the laboratories and upon disinfection. For the former work there were available both mobile field laboratories, arranged on motor trucks, and also portable laboratories. The apparatus and chemicals of the latter were arranged in chests.

In addition to the above mentioned laboratory equipment for bacteriological analyses and for those chemical tests necessary in connection with chlorination, there were available toxicological outfits provided by the Medical Department for use in connection with possibly poisoned waters which might be encountered. It must be said, however, that neither the British, the French, nor our own Army encountered any water which had been poisoned with any intent to deceive, though of course there were many cases of intentional pollution.

Chlorine gas and hypochlorite of lime were the elements upon which principal reliance was placed for disinfection. In addition a certain amount of javellization was done. This is a process, in common use in the French Army and named after its French originator, consisting in the application of a solution of sodium hypochlorite, usually by hand dosing.

The most universally useful piece of equipment was the water purification truck manufactured for the U. S. Army by the Wallace

& Tiernan Company. There were two types of these. The less useful one is known by the trade name of "Chloropump" and contains a pump with an automatic, solution feed, chlorinator. The more useful type,[2] known by the trade name of "Sterilab," includes the pump and chlorinator of the former and in addition a Roberts pressure filter, with alum pot, etc. In addition both types of water purification trucks were equipped with complete laboratory apparatus for bacteriological and chemical work.

Starting on August 17, in preparation for the pending St. Mihiel offensive, with one officer at Army Headquarters and one-half company of troops in the area of the proposed operation, the First Army Water Supply Service reached a total of 1800 men, including 54 officers, for the purpose of that operation. Later the personnel increased to a maximum of 3400 men, including 115 officers. Its personnel was somewhat decreased when the American Second Army was organized and took over the area over which the St. Mihiel operation had taken place, whereas the First Army continued pressing the Argonne-Meuse offensive.

Closely allied with the work of the Water Supply Service was that of the Divisional Sanitary Inspectors of Water, of whom there was one with each division. These officers were sanitary engineers, including for instance 1st Lieutenant P. O. Collins with the 26th Division and Captain L. A. Fritze with the 42d Division, both members of this Association.

Here and there a piece of more ambitious work was carried on. Thus in the last two weeks preceding the St. Mihiel drive there was conceived and constructed in the Foret de Puvennelle a system for supplying water to men and animals secretly concentrated in these large woods, extending well up to the front line. The development included a pumping station constructed in a chamber driven into the rock of a hillside, for protection against enemy shell fire. Two gasoline driven triplex pumps of 60 gallons per minute capacity at 460 feet head were installed, drawing water from a stream at the base of the hillside. A difference in elevation of 300 feet was overcome. The intake arrangement included a coagulation basin and means for automatic chlorination. Approximately six miles of 4-inch and 2-inch pipe lines were installed, together with a number of reservoirs, of which one had a capacity of more than 10,000 gallons,

[2] See JOURNAL, September, 1919, p. 562.

and a system of hydrants for water cart and motor tank train filling, etc. Also horse watering facilities were installed.

The need for speed, however, was even greater in the Argonne-Meuse operation. Thus the Water Supply Officer, First Army, in common with others of the engineer staff of the Army, received the first notice of the operation on September 11, the day before the St. Mihiel attack. So great was the pressure of the St. Mihiel operation that reconnaissance of the Argonne-Meuse territory could not be begun until September 16; yet all arrangements had to be complete, and were completed, for the first Argonne-Meuse attack by dawn of September 26.

For that operation the American First Army made a marvellous record in the way of troop movement. Hundreds of thousands of men were transported from the St. Mihiel area and from the rear into the new area where until several days before the attack there had been practically only French troops in the front lines. This shifting of troops had to be done at night and with a minimum of available motor transportation. Even in the case of water supply troops, great as was the immediate need in the new area on account of the pending concentration, one of the companies had to spend three nights on the march, passing through bombed territory at that.

For each "drive" the Army Water Supply Service, like all other branches of the army, had its battle plan. Thus figure 7 shows the schematic plan for Water Supply in connection with the culminating Argonne-Meuse attack, that of November 1. The "Districts" indicated are those referred to in Figure 1. For convenience the boundaries between Districts were fixed as north and south lines, thus differing considerably from the army corps boundaries. Immediately following the attack on the morning of November 1, "F" District, for instance, sent forward four advance parties which had previously been posted at positions indicated on the plan as 1a, 2a, 3a and 4a, respectively, near the center of the "jumping off" line.

Each of these parties was composed of about 25 men with a mule-drawn wagon-load of materiel for installing emergency water supplies. Advance Party No. 2, for example, was under orders to set up water points as closely as practicable to positions 2b, 2c, 2d, 2e and 2f. The schematic plan also shows the dispositions to be made, immediately prior to the atttack, of the resources of the Water Supply Service available for the purpose, as regards both materiel and personnel.

Before leaving the subject the speaker desires to pay tribute to

the splendid character of the personnel comprising the rank and file of the Water Supply Service. The 26th Engineers alone included members from all states of the Union except two, and, besides,

FIG. 8. THE REMAINS OF A FRENCH RAILWAY WATER TANK AT APREMONT (ARGONNE)

This is a view of typical conditions in the battle area, which made emergency installations necessary.

members from Alaska and the Canal Zone. In general the men were real "doughmen" rather than "doughboys," men who knew what

kind of work they were volunteering for, and who were skilled at that work. Especially versatile were the oil field workers from Texas and California.

Though not normally engaged in front line work, yet their positions subjected them to continuing danger and at times their work carried them even into No-man's Land. Like other army troops, they were subjected to hazard without the opportunity to fight back. The greater part of the army water supply work was carried on in the area just ahead of the heavy artillery and just back of the light artillery —an area exposed to frequent enemy shell fire. Even those engaged in the work of quality control were subjected to the hazard. Thus First Lieutenant Joseph Tinsman, Sanitary Corps, Company F, 26th Engineers, was severely wounded on November 4 and gamely fought death until he was forced to succumb November 17, the very day when the American Army of Occupation, including Companies C and F, 26th Engineers, started its march toward the Rhine.

Aside from the above mentioned difficulties there were the hardships due to poor shelter, scarcity of blankets and difficulties in obtaining rations for troops so widely scattered. Infantry divisions would go into the line for days or weeks according to the severity of fighting and then come out and go to the rear for rest. But the First Army troops received no relief whatsoever during the entire campaign. Some of the Water Supply troops were at work on active fronts beginning in the Chateau-Thierry region in August and continuing to the very day of the armistice. The Water Supply troops performed a task which was not easy and, judging by the lack of complaint, performed it well.

SCHOHARIE DEVELOPMENT OF THE CATSKILL WATER SUPPLY SYSTEM FOR NEW YORK CITY

By J. Waldo Smith

With the award of the Gilboa dam contract on June 23, 1919, of the highway contract on June 13, 1919, of the Shandaken tunnel contract on November 9, 1917, and with the acquisition of title to the necessary property in 1917, construction activities on the Schoharie development are well under way. The Schoharie source, which is adjacent to and immediately north of the Esopus, will furnish the necessary water, 250,000,000 gallons a day, supplementing the 250,000,000 gallons from the Esopus source already reaching the city, to supply 500,000,000 gallons a day which the Catskill aqueduct will carry. The construction progress required by the contracts is such as to complete the work by the end of 1924. The estimated cost of the project is $22,175,400. Thus the Catskill system will be extended 36 miles north from the Ashokan dam, making an overall distance for the system of 156 miles from the new dam to the terminal reservoir on Staten Island.

The original Catskill plan. The original comprehensive plan prepared by the Board of Water Supply and adopted by the Board of Estimate and Apportionment in 1905 provided for the building of structures sufficient to gather, filter and convey to the city not less than 500,000,000 gallons daily of water from the Catskill Mountain sources. These sources were Esopus, Rondout, Schoharie and Catskill creeks, which it was estimated could yield 250,000,000, 125,000,000, 136,000,000, and 149,000,000 gallons a day respectively, aggregating together 660,000,000 gallons a day from which the 500,000,000 gallons a day of Catskill Mountain water would be obtained.

First development. The first stage has been completed and in operation since 1917. This included the construction of the Ashokan reservoir, developing Esopus creek to furnish 250,000,000 gallons a day, and the Catskill aqueduct and appurtenances with a carrying capacity of not less than 500,000,000 gallons a day. The Ashokan

Statistics of Ashokan, Kensico and Schoharie Reservoirs

	ASHOKAN STORAGE RESERVOIR	SCHOHARIE STORAGE RESERVOIR	KENSICO EMERGENCY RESERVOIR
Capacity, total	130,000,000,000 gallons	22,000,000,000 gallons	38,000,000,000 gallons
Capacity, available	128,000,000,000 gallons	20,000,000,000 gallons	29,000,000,000 gallons
Water surface	12.8 sq. miles = 8,180 acres	1.83 sq. miles = 1,170 acres	3.5 sq. miles = 2,218 acres
Land, acquired	23.8 sq. miles = 15,222 acres	3.72 sq. miles = 2,372 acres	7.0 sq. miles = 4,500 acres
Elevation of top of dam, above tide	610 feet	1,130 feet	370 feet
Length of reservoir	12 miles	5 miles	4 miles
Length of shore line	40 miles	12 miles	30 miles
Length of dams and dikes	5½ miles	2,300 feet	3,300 feet
Main dam:			
Total length	4,650 feet	2,300 feet	1,825 feet
Length of masonry portion	1,000 feet	1,300 feet (Earth, 1,000 feet)	1,825 feet
Height (maximum)	252 feet	160 feet	307 feet
Thickness at base (maximum)	190 feet	165 feet	235 feet
Thickness at top (minimum)	23 feet	15 feet	28 feet
Width of reservoir:			
Maximum	3 miles	4/5 mile	3 miles
Average	1 mile	2/5 mile	1 mile
Depth of reservoir:			
Maximum	190 feet	140 feet	155 feet
Average	50 feet	58 feet	52 feet
Villages submerged	7	1	1
Permanent population of submerged area at beginning of work	2,000	350	500

Cemeteries removed	32	7	None
Bodies reinterred	2,800	1,330	None
Railroad relocated	11 miles	None	None
Highways discontinued	64 miles	13.6 miles	14.8 miles
Highways built	40 miles	12.4 miles	15.1 miles
Highway bridges built	10	2	4
Earth and rock excavation	2,500,000 cubic yards	488,500 cubic yards	1,400,000 cubic yards
Embankment	7,300,000 cubic yards	617,000 cubic yards	2,010,000 cubic yards
Masonry	900,000 cubic yards	436,000 cubic yards	965,000 cubic yards
Cement	1,200,000 barrels	480,000 barrels	897,000 barrels
Maximum number of men employed	3,000		1,500

reservoir, however, was constructed of the largest practicable size, 128,000,000,000 gallons available storage, in order to care not only for the requirements of storage for the Esopus, but also to provide storage, something like 45,000,000,000 gallons as it was worked out theoretically, for the Schoharie or Catskill creeks.

The storage of water began in Ashokan reservoir when the opening through the dam was closed on September 9, 1913; the first filling of Kensico reservoir began on November 22, 1915, three years ahead of contract time; Catskill water was delivered to Bronx borough December 27, 1915, to Manhattan borough November 29, 1916, and to all boroughs, including Brooklyn, Queens and Richmond, on January 22, 1917, and continuously thereafter.

Authority to develop Schoharie. In 1906, in approving the city's petition for permission to take water from the Catskill watersheds in accordance with the comprehensive plan, approval as to the Schoharie was denied because of a legal technicality. Meanwhile, during the construction period of the first stage in 1907, 1912 and 1914, the petition to the State Water Supply Commission and its successor, the State Conservation Commission, to take the waters of Schoharie creek was renewed, being approved in 1914. With this approval came the time when the city was at liberty to plan for the development of any or all of the sources in the original plan as should prove necessary to complete the supply of 500,000,000 gallons a day.

Rondout source abandoned. Subsurface investigations of dam sites were carried on intermittently, though fairly constantly, since 1907 in the Rondout and Schoharie valleys. Many locations for a dam site were investigated on the Rondout, which is contiguous to the aqueduct on the west, but none was found which the engineers could recommend. The pre-glacial gorge was found to be very deep and to one side of the present stream bed. There was an over burden of glacial drift, then a bed of clay was penetrated, after passing through which in many places the casings used in the boring work would sink many feet of their own weight or with very little resistance through a superfine sand or quicksand, and accompanied in most instances by continuous artesian flow of water under pressure. These conditions, found to be general in that section of the valley available to the project, would increase the cost of construction of a dam beyond reasonable amounts, even if practicable methods of construction could be devised. One flowing boring proved to be a

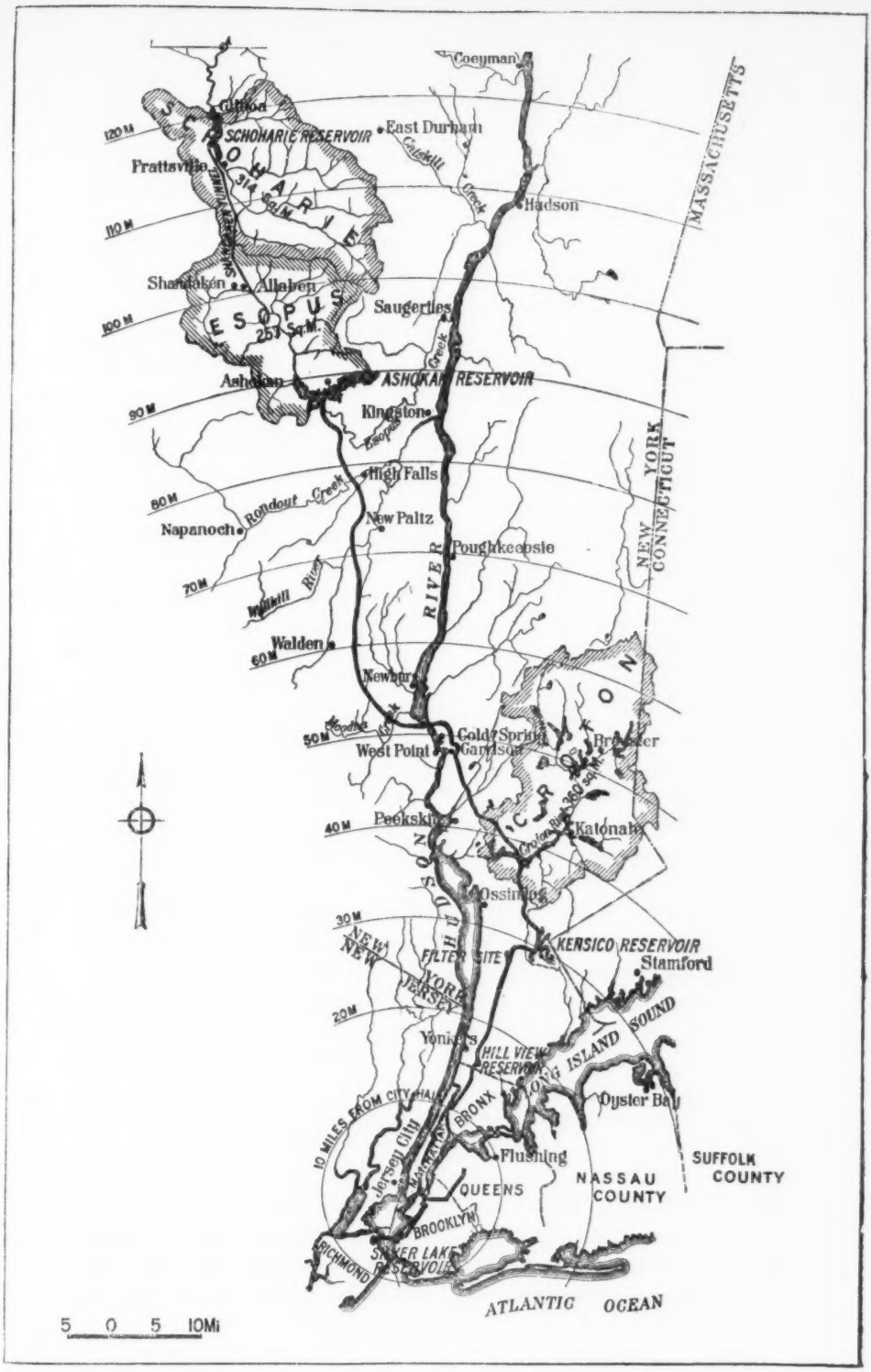


FIG. 1. MAP OF THE CATSKILL WATER SYSTEM FOR THE CITY OF NEW YORK

very persistent producer. The ordinary methods of plugging it were unavailing. Many carloads of cement were injected as grout in an attempt to seal the clay bed penetrated, without permanent success; if stopped in one place it would break out nearby. This flowing water carried considerable turbidity and a crater of appreciable size was formed. Finally the city purchased a few acres about it and filled in the crater each year for three or four years with one-man stones and gravel, with the idea of forming a natural rock spring, thereby clarifying the discharge. With this method of treatment the flow has now ceased.

On account of the unfavorable physical conditions and consequent greatly increased cost of developing the Rondout, the original plan of going there for the second source and to the Schoharie or Catskill for the third source had to be reconsidered, with the result that the Rondout was finally abandoned.

Catskill source early set aside. Extensive detailed investigations were never made of dam sites on Catskill creek, which lies to the northeast of Ashokan reservoir on the easterly slopes of the mountains. The 32½ mile aqueduct, eight reservoirs on five streams, the low rainfall of 34.66 inches per annum combined with low run-off reducing the early estimated safe yield from 149,000,000 gallons a day to 120,000,000 gallons, altogether formed such a combination of unfavorable factors, disclosed early in the investigations, as to cause Catskill creek to be considered as an alternative source for possible future use. A preliminary estimate of cost for developing this source was $41,880,000.

Schoharie source with dam at Prattsville. The sub-surface investigation in the Schoharie valley indicated a satisfactory dam site at the original location, the village of Prattsville, where the contemplated reservoir would have had a flow line at elevation 1240 feet above sea level and a storage capacity of 9,500,000,000 gallons. From the Prattsville reservoir the tunnel to the Esopus valley would have been 10 miles long. The accurate records of stream flow disclosed that the Schoharie has a higher yield than previously had been estimated. The rainfall is very close to that originally estimated, but the percentage of it appearing as stream flow is much higher, so that the yield compares favorably with the Esopus. Of the 47 inches depth of rainfall in a year on the Esopus watershed, 29.5 inches (63 per cent) appears as stream flow, while the Schoharie, with only 39.5 inches of rainfall, yields 27.2 inches (69 per cent) as

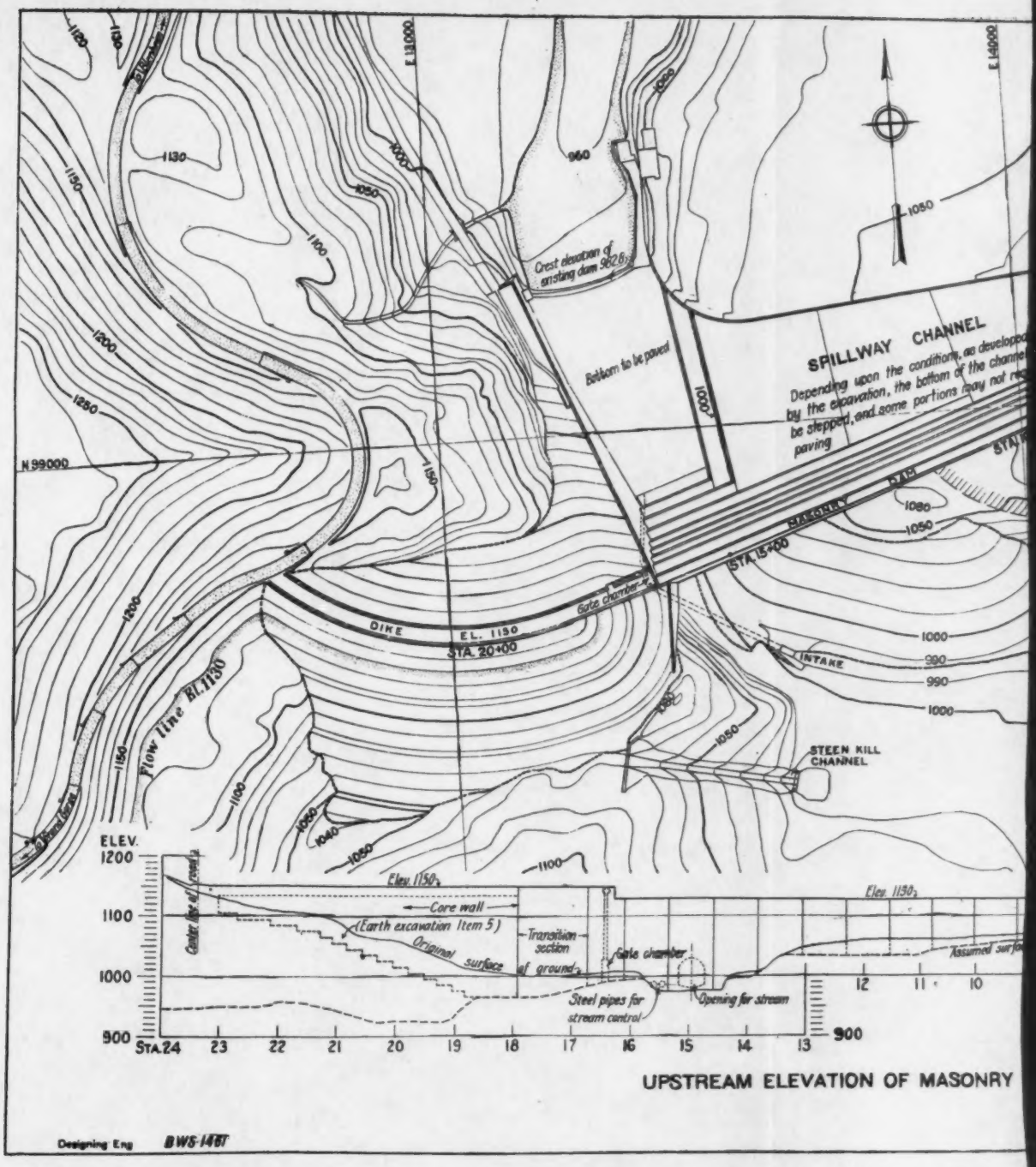
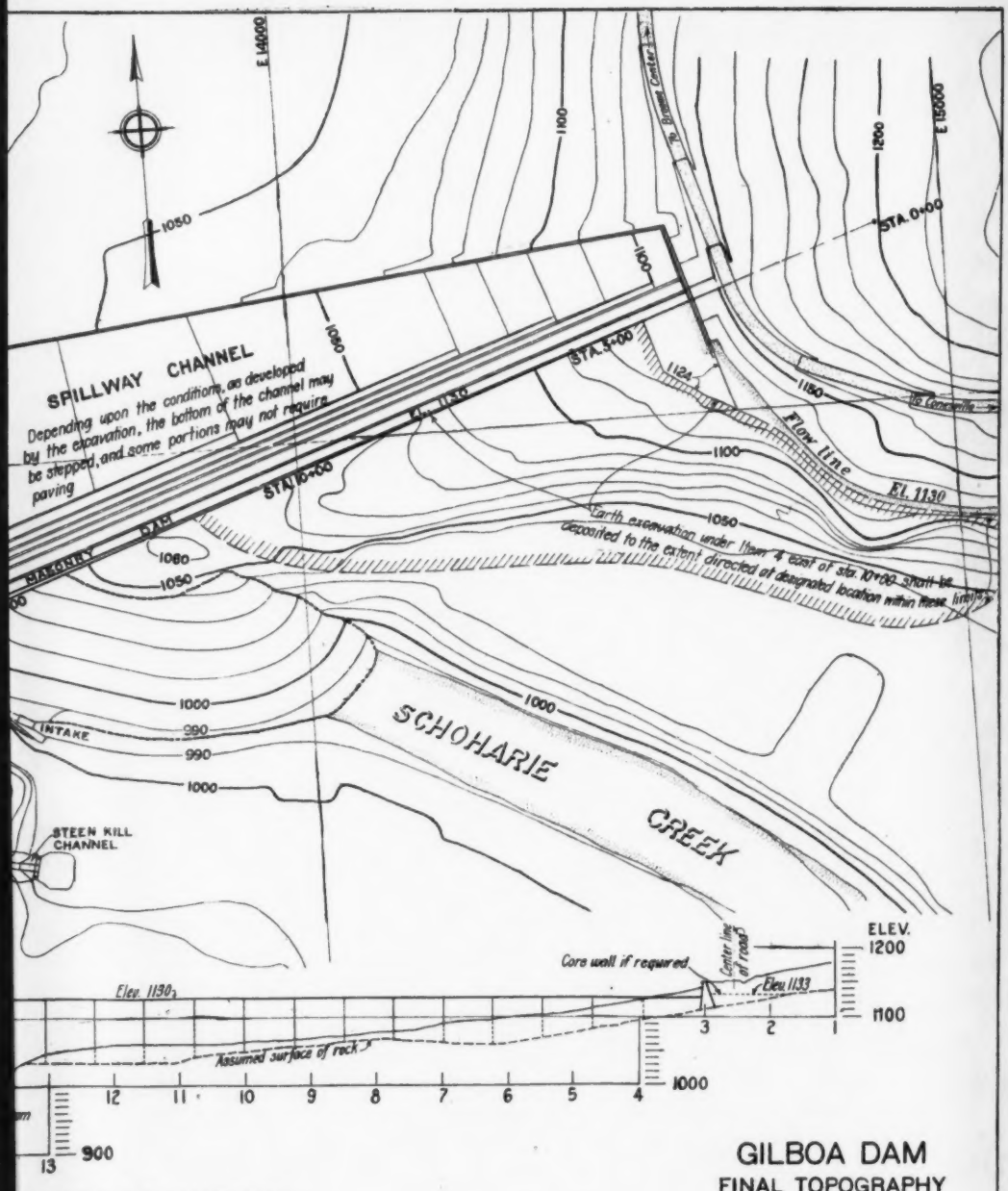


FIG. 2. PLAN OF THE GILBOA DAM AND ELEVATION OF THE MA



M AND ELEVATION OF THE MASONRY PORTION

stream flow. Compared with these, the Croton yields 22.4 inches of stream flow, and the Wachusett watershed of the Boston supply yields but 21.3 inches of stream flow on the average.

With these favorable conditions it was found that the estimated safe yield from the 226 square miles of catchment area above Prattsville should be increased from 136,000,000 gallons a day to 200,000,000, leaving therefore, only 50,000,000 gallons a day shortage in the full aqueduct supply. The estimated cost of the Schoharie development with dam at Prattsville was $14,216,000. This plan has been amended as hereinafter outlined.

Schoharie source with dam at Gilboa. Consideration was then given to the possibility of securing 250,000,000 gallons a day from the Schoharie by placing the dam further down stream. Borings, aggregating nearly five miles in depth, were made and the ground between Devasego Falls and Gilboa was well covered by surveys and examinations. The results of these investigations disclosed that the most practicable site for the necessary dam would be at Gilboa. The drainage area above this location is 314 square miles. The dam will be 160 feet high above the stream bed, forming a reservoir with flow line 1130 feet above sea level, containing storage of 22,000,000,000 gallons, of which 20,000,000,000 gallons will be available. This will act as a diverting reservoir as well as a storage reservoir and will be operated in conjunction with the Ashokan by means of the tunnel to Esopus creek. The tunnel will extend 18 miles from about a mid-point on the reservoir, discharging into Esopus creek at Allaben, where the water will mingle with the water of Esopus and follow the natural channel bed of Esopus for 11 miles into Ashokan reservoir. The tunnel will have a capacity of 600,000,000 gallons a day, which is double the average supply to be drawn, the large capacity being necessary to transport the water to Ashokan during times of plenty. The Esopus and Schoharie sources to contribute to the Catskill Mountain Supply have the following features:

RESERVOIR	DRAINAGE AREA	RESERVOIR AREA	AVAILABLE STORAGE	PROBABLE MEAN STREAM FLOW A DAY
	sq. mi.	*sq. mi.*	*gallons*	
Ashokan	257	12.78	128,000,000	361,000,000
Schoharie	314	1.83	20,000,000	406,000,000
Combined	571	14.61	148,000,000	767,000,000
Kensico	22	3.47	29,000,000	18,000,000
Total Catskill System	593	18.08	177,000,000	785,000,000

FIG. 3. THE SITE OF THE GILBOA DAM

The studies indicate that during large floods and for short periods there will be some waste at both reservoirs. On the other hand the heavy draft will cause rapid depletion of the reservoirs each year, normally exceeding 60,000,000,000 gallons, and with two or three unfavorable years in succession the depletion may reach 100,000,000,000 gallons.

The estimated cost of the Schoharie development with dam at Gilboa was $22,175,400.

The results of the studies and investigation showed: (1) that the Schoharie watershed is the one most available for completing and rounding out the full Catskill supply of 500,000,000 gallons a day; (2) that the proposed location of the dam at Gilboa removes the uncertainty of the foundation problem encountered on the Rondout; (3) that the cost of developing the Schoharie watershed is less than the cost of developing any other available source; (4) that the development of the Schoharie will complete the Catskill mountain supply as authorized.

Amended Schoharie plan. On December 22, 1915, the Board of Water Supply submitted a report with amended map, plan and profile, with the dam located at Gilboa, to the Board of Estimate and Apportionment, which after due advertisement in all counties, by or through which water from Schoharie creek naturally flows, which included all those bordering the Schoharie creek, the Mohawk and Hudson rivers, held public hearings and approved the project on January 31, 1916. A petition was immediately submitted to the State Conservation Commission. On due advertisement in all counties affected, hearings were held by it. In moving the dam-site down stream, the land for the reservoir site was located in two counties in addition to those specified in the Statute, Chapter 724 and 725 of the Laws of 1905, wherein special provisions for damages to lands and businesses not taken are allowed. Thus it was necessary to go to the Legislature before the Conservation Commission could certify that the plans were just and equitable to the civil divisions of the State. With these provisions of the statute corrected, the Conservation Commission approved the amended project on June 6, 1916.

Preliminary work. The land-taking surveys were begun in July, 1916, and detailed sub-surface investigations by borings for the tunnel location and for the dam foundation were prosecuted in 1916

and 1917. This work was at first concentrated on the tunnel, as it will take longer to construct than to build the dam. There were 16,800 linear feet of borings made in definitely fixing the tunnel line, grade and shaft sites, while an additional 8,400 linear feet of borings were made at the Gilboa dam site, these together totaling 4.8 miles in addition to the preliminary borings previously mentioned. The agreement prices of these borings ranged from $2.25 to $3.00 per linear foot, the average price being $2.50.

The property has been acquired by condemnation as provided by the special act under which the Board is operating. There is a provision by which title becomes vested in the City at the time the commissioners of appraisal file their oaths of office and upon the City paying one-half the assessed valuation. The City became vested with the real estate, 80 acres fee, 49 acres easement, total 129 acres for the tunnel and shaft sites, on May 25, 1917, and that for the reservoir, 2372 acres fee with 2 acres road easements, on November 24, 1917; aggregating 2503 acres. The preliminary work of definite location and surveying, mapping and formalities of securing the property thus consumed about a year and a half from the date of the final approval of the project.

The Gilboa dam. Contract 203, for the Gilboa dam and appurtenances, was awarded on June 23, 1919, to the Hugh Nawn Contracting Company, Roxbury, Mass., the amount based upon contract quantities and unit prices being $6,819,910. The dam will be located in the town of Gilboa, Schoharie County, about four miles northeast of the Grand Gorge station of the Ulster & Delaware railroad. This is 66 miles by rail from Kingston and 155 from New York.

The dam will be of two distinct types. On the east side of Schoharie creek and in the bottom to the stream the rock is at or near the surface; on this rock foundation will be constructed an overfall masonry portion 1300 feet long and 160 feet high. The west bank is composed of a very stiff impervious clay, which extends in every direction, and the preglacial gorge of the stream is completely filled and deeply covered with tight and impervious material; for this side of the stream an earth embankment portion 1000 feet long and approximately the same height as the masonry portion will be built. At the transition section the dam will be flanked both upstream and downstream by a heavy masonry retaining wall to intercept the long slopes of the earth section.

The overfall section is designed with steps on the downstream side

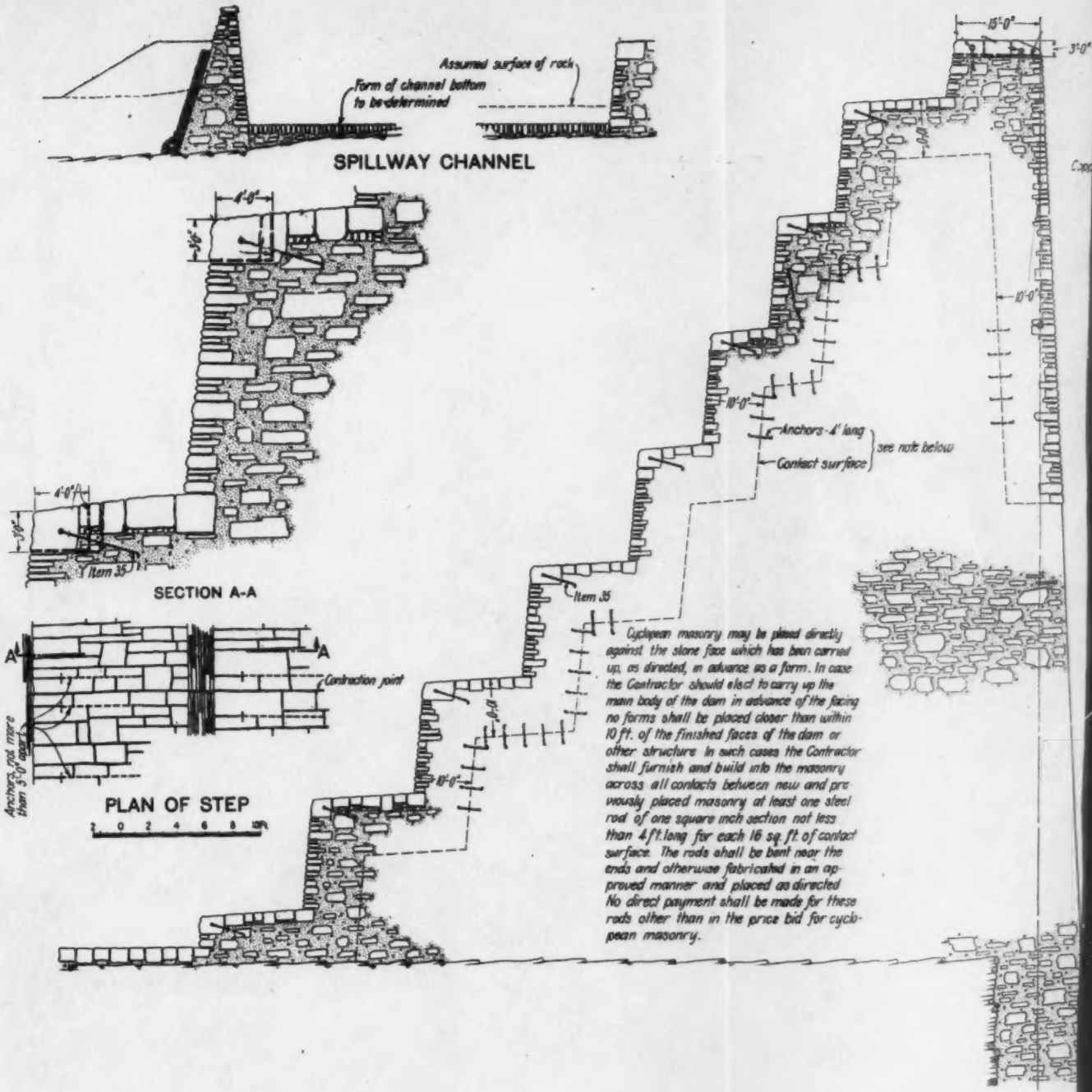
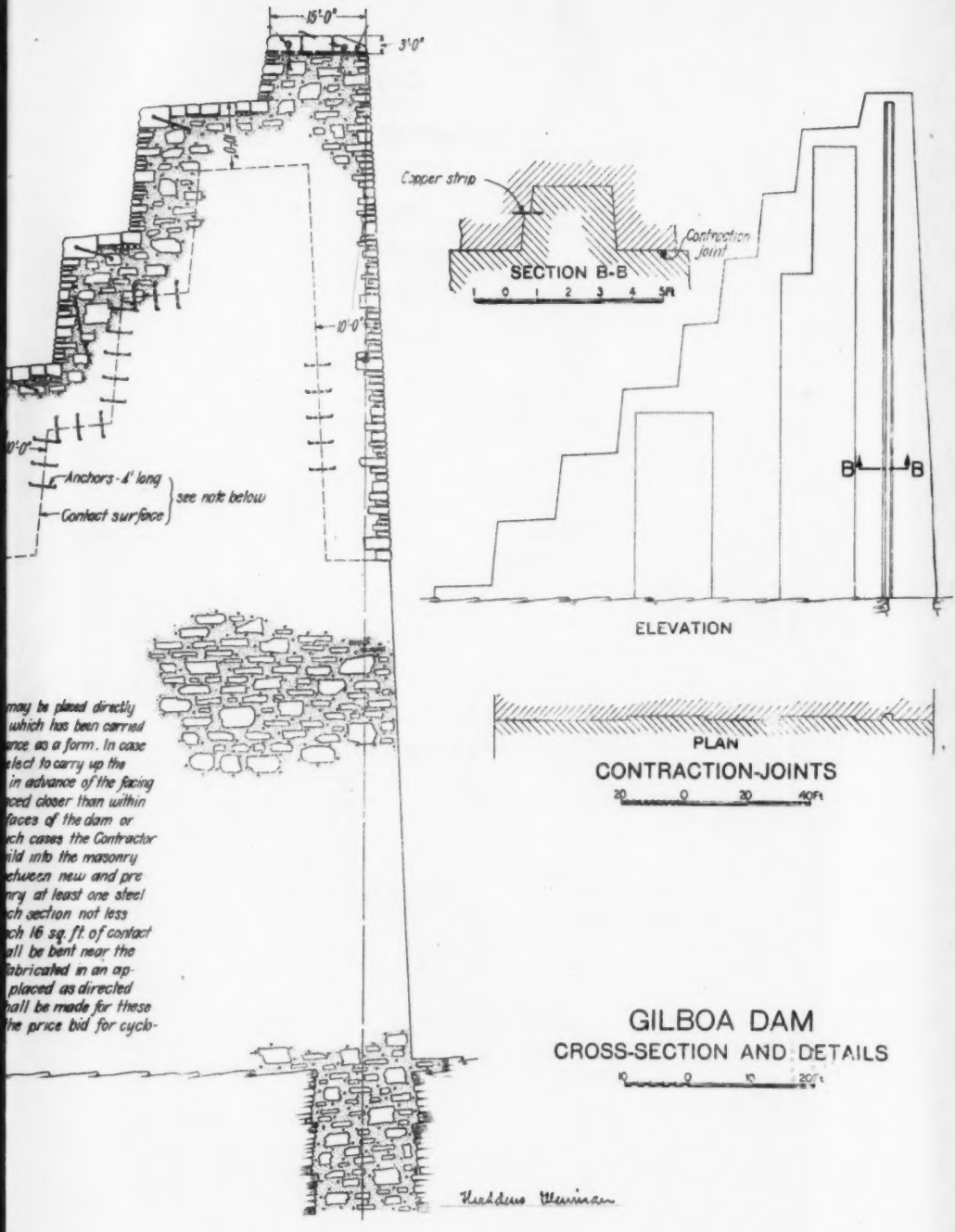

Assumed surface of rock
Form of channel bottom to be determined
SPILLWAY CHANNEL
4'-0"
3'-6"
4'-0"
3'-6"
Item 35
SECTION A-A
A
A
Contraction joint
Anchors, not more than 5'-0" apart
PLAN OF STEP
2 0 2 4 6 8 10
15'-0"
3'-0"
10'-0"
10'-0"
Anchors - 4' long
Contact surface
see note below
Item 35
6'-0"
10'-0"
Cyclopean masonry may be placed directly against the stone face which has been carried up, as directed, in advance as a form. In case the Contractor should elect to carry up the main body of the dam in advance of the facing no forms shall be placed closer than within 10 ft. of the finished faces of the dam or other structure. In such cases the Contractor shall furnish and build into the masonry across all contacts between new and previously placed masonry at least one steel rod of one square inch section not less than 4 ft. long for each 16 sq. ft. of contact surface. The rods shall be bent near the ends and otherwise fabricated in an approved manner and placed as directed. No direct payment shall be made for these rods other than in the price bid for cyclopean masonry.

FIG. 4. SECTIONS OF THE GILBOA DAM AND SPILLWAY CHANNEL



GILBOA DAM AND SPILLWAY CHANNEL

for the purpose of breaking up and safely conducting the overflowing water down the face of the dam to the spillway channel below. All the masonry will be concrete into which stones may be imbedded in the sizes and proportions found practicable. All exposed surfaces are to be of selected native sandstone with mortar joints. The earth portion of the dam is of conventional design with masonry corewall and with heavy rock paving on the upstream slope.

The spillway channel, along the toe of the dam, which will discharge waste waters into Schoharie creek below, is about 80 feet wide at the upper end and 300 feet at the lower; the rock bottom slopes rather steeply and will be protected where necessary with masonry and substantial paving. The side of the channel away from the dam will be defined by a masonry retaining wall. A field model of the overfall section and the spillway channel is now being constructed by the engineers to determine certain details necessary to properly control the overflow.

The contract includes also the construction of about three miles of highways which must be completed before active operations on the dam can begin.

The stream control scheme during construction outlined in the contract is similar to that used at Ashokan dam, involving the placing of first, two large steel pipes over the foundation cut-off trench and later the construction of an arched opening through the dam, 45 feet wide by 50 feet high, which will be filled with concrete when the dam is completed. There is also a permanent blow-off with 30-inch valve in duplicate. The principal items of the contract are 396,000 cubic yards of earth excavation, 92,500 cubic yards of rock excavation, 617,000 cubic yards of refilling and embanking, 436,000 cubic yards of masonry and 480,000 barrels of Portland cement. The contract time is 66 months.

The Shandaken tunnel. Contract 200, for the Shandaken tunnel, was awarded November 9, 1917, to The Degnon Contracting Company of New York City for $12,138,738 based on contract quantities and unit prices. As this is an unusually long tunnel it was considered advisable to divide the work into two parts upon which intending bidders might submit their proposals separately; but the low bid accepted for the entire tunnel was less than the sum of the separate part bids received. The main parts of the contract comprise the intake works, the tunnel and the outlet works.

The intake works will be located about 3 miles north of the village of Prattsville and 2 miles south of the dam on the westerly side of the reservoir. They will consist of an intake channel and chamber with superstructure and an intake shaft. The chamber will be built into the rock and will house eight 3- by 7-foot sluice gates set radially in the wall of the central well or extension of the intake shaft. The superstructure will have rubble walls of native bluestone, re-inforced concrete floors, steel roof trusses and steel framing for the crane over the intake shaft. This building will have two wings, providing living quarters, garage, office, machine shop and store rooms. The intake shaft will be 14 feet in diameter, except where constricted near the top by a Venturi meter.

The tunnel extending from the intake works in a general south-easterly direction for a distance of 18 miles to the outlet works, to be located on the upper reaches of the Esopus creek just south of the village of Allaben, will be of sufficient size and gradient to transport water from Schoharie reservoir to the upper reaches of Esopus creek at the rate of 600,000,000 gallons a day. The velocity of the flowing water will be 8.7 feet per second, equals 5.9 miles per hour, acting as a grade tunnel. The tunnel will be operated intermittently at varying rates, depending on the conditions of stream-flow and storage. The intake sill will be at elevation 1050 and the outlet channel weir will be at elevation 969. The tunnel will be in shale or sandstone, except for about 350 feet of tunnel in earth adjoining the outlet, and will be lined throughout with concrete.

The waterway section is of horseshoe shape, 11 feet 6 inches high by 10 feet 3 inches wide, inside dimensions, about 5.7 cubic yards of excavation per linear foot, and the tunnel will have a uniform grade of 4.4 feet per mile except for the northerly 3½ miles, which will be depressed in order to pass in rock of good quality beneath the gorge of the Bear Kill.

There are seven intermediate shafts, which will be permanent in order to provide ready access to the tunnel. The shafts will be lined with concrete and will have a diameter of 14 feet inside. Small superstructures of native stone will cap each shaft and guarded openings in the floor and walls of these buildings will provide for air movements in the tunnel. The aggregate depth of shafts will be 3,238 linear feet, the maximum depth of a single shaft being 630 feet. The minimum distance between shafts is 1.3 miles, the maximum 2.7 miles.

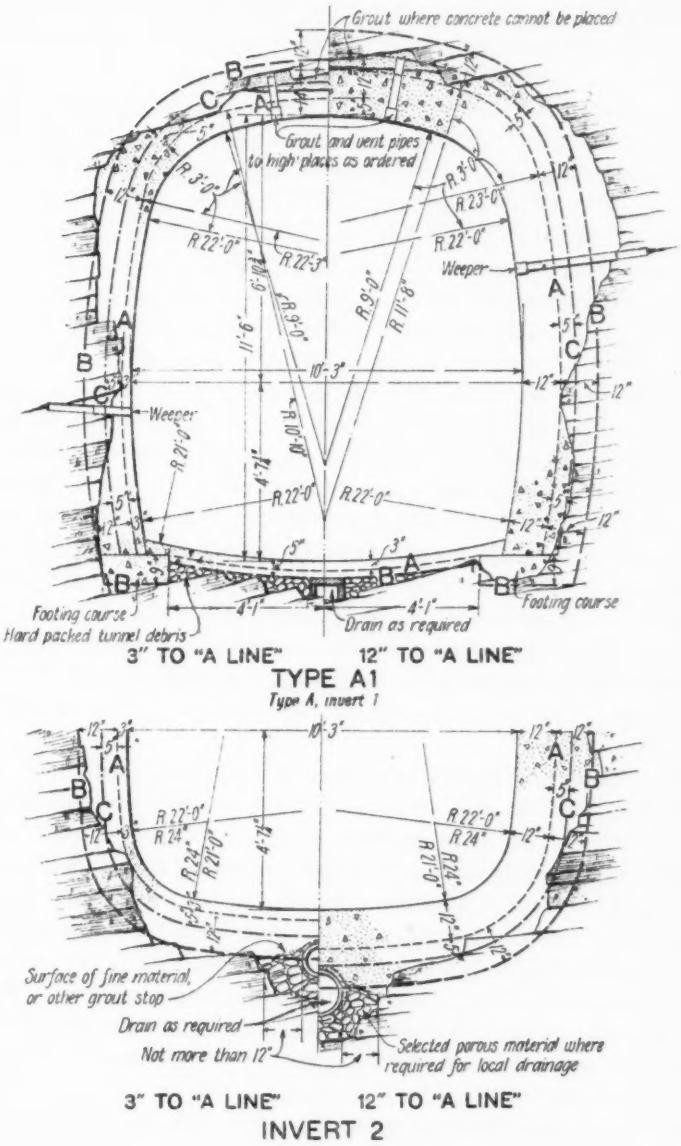


FIG. 5. SECTION OF SHANDAKEN TUNNEL

Invert 2 may be substituted for Invert 1 with any type of tunnel in rock

Work has been going on since the award of the contract and to July 16, 1919, about 2800 linear feet or 86 per cent of the total depth of shafts has been excavated and 2,560 linear feet or 79 per cent of the aggregate depth of shafts lined with concrete, the lining being placed in stretches following the excavation. Three of the shafts have reached tunnel grade and the others, except the intake shaft, are nearing it. The maximum weekly progress of shaft excavation in each of the seven shafts has been between 27 and 42 linear feet, and the average progress of all shafts 12 feet per week.

The outlet works at Allaben on Esopus creek will be located 11 miles above the Ashokan reservoir or 16 miles above the Ashokan dam. They will consist of about 500 feet of aqueduct of the cut-and-cover type, an outlet chamber and about 290 feet of open outlet channel. The cut-and-cover aqueduct will be of horseshoe shape, 11 feet 6 inches high by 10 feet 3 inches wide. Near the lower end it becomes a reinforced concrete waterway 11 feet 6 inches in diameter, with a fall of $16\frac{1}{2}$ feet, providing a water seal for the tunnel outlet. The outlet chamber will be an open flaring structure, whose invert will slope upward to the invert, elevation 969, of the open channel. The latter willl have masonry side-walls and local stone paving. Sloping gently for 290 feet and passing under a steel girder bridge, which will carry the highway, the channel will discharge the water from the tunnel into Esopus creek on its way to Ashokan reservoir.

The estimated contract quantities are about 600,000 cubic yards of rock excavation, 100,000 cubic yards of earth excavation, 200,000 cubic yards of concrete masonry and 445,000 barrels of Portland cement. The contract provides direct payment for medical services for the laborers and sanitary services for the camps and working locations. The shaft work has been done with individual plants at each location, but a power line is being constructed by the contractor to bring electric energy from Kingston for the tunnel work. Within 78 calendar months the work underground must be completed so that the tunnel can be operated, and all work must be completed within 7 years.

Highways and miscellaneous. Contract 202 for the grading of about $7\frac{3}{4}$ miles of highways around the Schoharie reservoir, was awarded on June 13, 1919, to the Schunnemunk Construction Company, Highland Mills, N. Y., for $176,700, based on the contract quantities and unit prices. The estimated quantities are 112,500

cubic yards of earth and rock excavation, 7,550 cubic yards of paving, masonry, etc., 6,500 barrels Portland cement and 22,000 linear feet of wooden guard rail. The contract time is 18 months.

Other Schoharie work not yet under contract will be a permanent highway bridge over Schoharie creek below the dam, a highway bridge and approaches over the Manorkill, a tributary of the reservoir, and the clearing of the reservoir site. To finish the main aqueduct to the City, additional tubes at 14 locations of steel-pipe siphons will be required.

FIELD METHODS FOR THE CHLORINATION OF SMALL AMOUNTS OF WATER

By F. R. Georgia[1]

In the area occupied by the First Depot Division of the American Expeditionary Forces there were no developed water supplies. The French inhabitants depended entirely on wells dug in the chalk for their water. These wells, which were usually open at the top and otherwise improperly protected, were all polluted. Bacteriological examination of a large number of them failed to discover even one that yielded a water of potable quality.

Since the divisional area embraced some 1000 square kilometers and had to handle as many as 70,000 Americans at one time, it was necessary to chlorinate small amounts of water derived from these wells at a large number of points. Most of this chlorination was carried out in Lyster bags. The supervision and control of these bags will be discussed later.

As the work of the division became better organized it became advisable to establish camps for special purposes where troops were concentrated in barracks or tents. At these points it was necessary for the engineers to construct wells in order to obtain sufficient water. Some of these, as at the Prison Camp and the Venereal Labor Camp, were simple open dug wells from which water was drawn by buckets and chlorinated in Lyster bags. At others, notably Camp Hospital No. 26, the Classification Camp, the Special Training Battalion and the 116th Supply Train, pumps driven by gasoline engines were provided, together with storage tanks and limited distribution systems.

Where such improvements were made, it was thought advisable to attempt some form of continuous purification of the water as it was pumped. The amounts of water handled varied roughly from 2000 to 15,000 gallons per day, and it was at first thought improbable that such small supplies could be successfully and satisfactorily

[1] The author served as First Lieutenant, Sanitary Corps, A. E. F.

Read before the Water, Sewerage and Sanitation Division of the American Chemical Society, Philadelphia, Pa., Sept., 5, 1919.

chlorinated without causing noticeable tastes in the water due to overdosage. The first of these supplies was developed at Camp Hospital No. 26, and since many of the patients objected to the tastes resulting from the chlorination of water in Lyster bags an attempt was made to chlorinate the entire supply as it was pumped.

For this purpose a home-made device, using chlorinated lime, was constructed. The original apparatus consisted merely of a barrel for storage of the stock solution of chlorinated lime, and a constant-level box fitted with a glass gauge and an orifice which consisted of a piece of soft rubber tubing with a screw pinchcock. It was necessary to calibrate the gauge in terms of the flow through this orifice. The solution was fed into a 1-inch galvanized iron pipe, which carried it down into the well to the end of the intake pipe of the pump. This apparatus consisted of parts *A* to *F* of the more complex apparatus shown in figure 1. The results obtained were highly satisfactory, as regards both bacterial removal and the absence of tastes in the treated water.

This led to the installation of a similar apparatus at the Special Training Battalion where similar results were obtained. Still another was installed at the 116th Supply Train, but no data are available, since the author left France immediately after it was set up. In addition to these home-made devices a Wallace-Tiernan liquid chlorine machine of the bubble meter, solution feed type was placed in use on the water supply of the Classification Camp.

Chlorination at Camp Hospital No. 26 was twice interrupted, due to the construction of new wells. The chlorinating device in use on this supply was finally modified to the more complex form described below, since this form allowed the suction line of the pump to be extended to other wells, without interrupting the chlorination, in case a larger supply became necessary.

But little trouble was experienced in the operation of any of these devices, once the proper strength of solution and rate of feed had been determined. It was necessary, however, to occasionally check up the men assigned to operate the machines. At one time the man operating the liquid chlorine machine allowed some chalky water to run through the apparatus and plug the valve where the chlorine water enters the suction line of the pump, with the result that all of the chlorine water went out the overflow. The trouble was located very shortly after a bad sample of water had been examined at the division laboratory. If the man had watched his apparatus he would have seen what was taking place.

At another time the man operating the machine at Camp Hospital No. 26 became ill and another man was placed in charge without being properly instructed in the operation of the chlorinating device. He operated the machine properly, except that he used only about one-fourth of the amount of chlorinated lime necessary to obtain proper results.

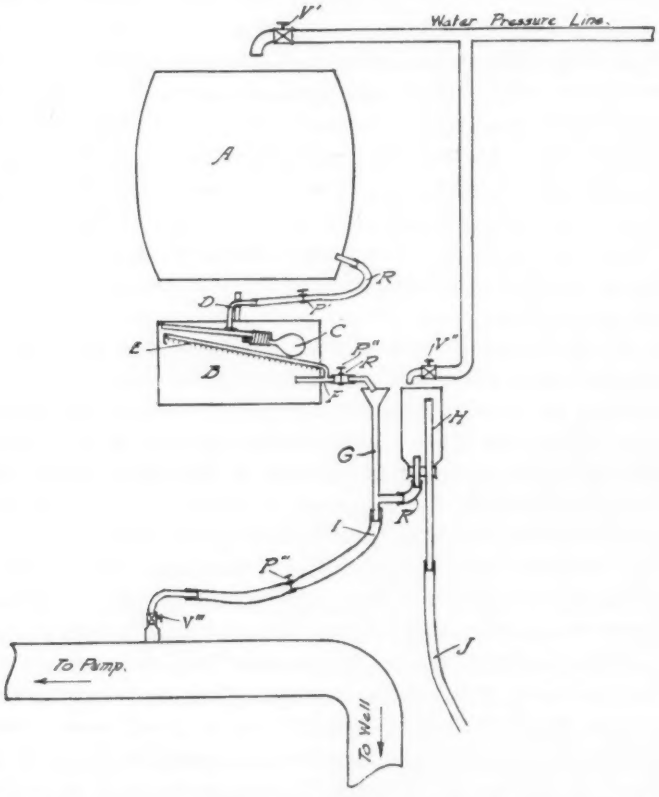


FIG. 1. APPARATUS FOR TREATING WATER WITH CHLORINATED LIME

A, Barrel for stock solution of chlorinated lime; *B*, constant level orifice box; *C*, constant level valve with glass float and rubber seat, hinged at end; *D*, glass tube which seats on *C*; *E*, gauge of glass for adjusting flow of solution; *F*, glass T-tube connecting with orifice; *G*, glass T-tube with funnel at top and connecting with water seal *H*; *H*, water seal of glass; *I*, heavy walled rubber tubing connecting *G* to suction pipe of pump; *J*, rubber tube for overflow from *H*; P^{I}, P^{II} P^{III}, screw pinch cocks; V^{I}, V^{II}, V^{III}, metal valves on pipe lines; *R*, connections of ordinary rubber tubing.

With the facilities available it was impossible to determine the amount of chlorine used with these special devices. Rather rough estimates would indicate, however, that the dosage was approximately one-half of a part per million of chlorine.

The device finally used at Camp Hospital No. 26 is shown in figure 1, and is followed by a description of the apparatus and its operation. Tables of some of the bacteriological results obtained are also included. The room temperature counts given are rather variable due to the fact that no room temperature incubator was available and the temperature in the laboratory was subject to rather large fluctuations.

In the operation of the chlorinating apparatus a stock solution of chlorinated lime, of proper strength, is made up in A, a water tap, V^{1}, being placed for convenience over the barrel. P^{1} being open, this solution flows into B until C seats on D, stopping the flow. P^{1} is closed only when the apparatus is not in use, being placed there to prevent the flooding of B in case the constant-level valve leaks slightly. The object of B is to maintain a constant level of solution and, therefore, a constant pressure on the orifice valve P^{11}.

P^{11} is opened until the gauge E indicates the proper flow of the solution. This gauge must be calibrated and the flow determined for different readings. If P^{111} and V^{111} are closed, the solution flowing through P^{11} will pass over into H and overflow through J. With the pump running, V^{111} is opened, after which P^{111} is opened *slowly* until the solution stops overflowing into J. Under these conditions, all of the solution flowing through P^{11}, plus a certain amount of air, will pass through V^{111} into the suction pipe of the pump. V^{11} is now opened allowing water to flow into H in sufficient quantity so that it overflows through J. Under these conditions, all of the solution passing through P^{11}, plus a small amount of water, passes through V^{111} into the suction pipe of the pump and all air is excluded.

The proper strength of solution and the amount of it to be used will vary with the capacity of the pump and the character of the water being treated, and must be determined for each case. The amount and strength of the solution to be used may, as a rule, be adjusted with a starch-iodide reagent but bacteriological control should be resorted to where possible.

After P^{111} has once been set it will not, as a rule, be necessary to change it unless the rate of the pump or the amount of solution used is changed.

TABLE 1

Bacteriological data on well at Camp Hospital No. 26

DATE	SOURCE	COLONIES PER CUBIC CENTIMETER ON AGAR		GAS PRODUCERS PER 100 CC. IN LACTOSE BOUILLON
		37.5°C.	Room temperature	
6/ 1/18	Pump*	8	140	14
6/ 1/18	Tap*	8	75	14
6/13/18	Pump*	43	175	50
6/26/18	Tap*	14	35	30
8/15/18	Pump*	65	40	60
8/15/18	Pump†	4	4	0
9/16/18	Pump‡	7	7	4
9/17/18	Pump‡	8	16	2
9/20/18	Tap‡	6	3	4
9/22/18	Tap‡	10	2	4
9/24/18	Pump‡	40	25	4
9/24/18	Tap‡	45	15	0
9/30/18	Tap§	5	3	0
10/ 8/18	Tap	1	1	0
11/ 4/18	Tap¶	1	15	4
11/ 6/18	Tap¶	0	5	0
11/ 7/18	Pump**	5	45	0
11/ 9/18	Tap	4	4	0
11/23/18	Tap	1	2	0
12/ 4/18	Tap††	25	6	4
12/10/18	Tap‡‡	7	120	100+
12/11/18	Tap§§	60	140	100+
12/12/18	Tap§§	20	60	100+
12/13/18	Tap§§	1	10	0
12/18/18	Tap	4	5	0

* First well before chlorination.

† First well after chlorination was started.

‡ Results on second well, which drained the first one. The same chlorinating device was used and the rate of feed readjusted.

§ Water pronounced potable.

¶ Old wells replaced by a third and larger one. A larger pump was installed and the chlorinating device modified to the form shown in figure 1.

** This sample taken, plated and 50 cc. inoculated into fermentation tubes within two minutes after the water was chlorinated. The results show the rapid action of chlorine on bacteria and especially on gas producers and other forms growing at 37.5°C., when dealing with clear, colorless waters, as in this case.

†† System contaminated by changes in pipe lines and storage tanks.

‡‡ New operator placed in charge of pump. Results due to his feeding less than one-fourth of the required amount of chlorinated lime.

§§ Results show return to normal when the proper amount of chlorinated lime was fed.

After the proper strength of solution has been determined and P^{III} has been adjusted, the following procedure should be followed in starting the apparatus:

Open P^{I}, adjust P^{II} to the proper flow, and open V^{III} before the pump is started. Start the pump and note whether the overflow at J stops. If it does open V^{II} until it starts to overflow again. If an overflow is obtained with V^{II} closed while the pump is running, P^{III} must be opened until this overflow stops.

TABLE 2

Bacteriological data on well at Special Training Battalion

DATE	SOURCE	COLONIES PER CUBIC CENTIMETER ON AGAR		GAS PRODUCERS PER 100 CC. IN LACTOSE BOUILLON
		37.5°C.	Room temperature	
8/23/18	Pump*	1,800	2,000	100+
9/17/18	Pump†	3	2	0
9/17/18	Pump	2	3	0
9/23/18	Pump	1	20	0
9/23/18	Tap‡	75	40	4
9/30/18	Tap§	1	1	0
10/ 2/18	Tap	0	1	0
10/ 8/18	Tap	0	0	0
10/12/18	Tap	1	0	0
10/27/18	Tap	1	2	0
11/ 1/18	Tap	2	3	0
11/ 8/18	Tap¶	300	450	90
11/12/18	Tap**	2	2	0
12/ 4/18	Tap	0	0	0
12/10/18	Tap	0	5	0
12/18/18	Pump	7	8	0
12/20/18	Pump	8	15	0

* Before chlorination.

† After chlorination.

‡ Storage tanks and pipes not flushed out.

§ Water pronounced potable.

¶ Engine broke down, system drained and one tank partly filled with unchlorinated water.

** New engine installed.

To shut down, stop the pump first and then close V^{III}, V^{II}, P^{II} and P^{I} in the order named.

The Lyster bag is a canvas container lined with rubber, provided with five self-closing faucets near the bottom, a canvas cover to keep out dirt and a metal ring at the top from which it is supported by means of ropes. It has a capacity of about 36 gallons.

Sealed glass tubes containing 1 gram of chlorinated lime, having 30 per cent of available chlorine, were provided for the chlorination of these bags. One of these tubes was sufficient to impart a chlorine content of 2.2 parts per million to the water in one bag. Almost without exception this was enough to decidedly over-chlorinate the waters dealt with and to impart to them a rather pronounced taste. These tastes might have been eliminated by using smaller amounts

TABLE 3

Bacteriological data on well at Classification Camp

DATE	SOURCE	COLONIES PER CUBIC CENTIMETER ON AGAR		GAS PRODUCERS PER 100 CC. IN LACTOSE BOUILLON
		37.5°C.	Room temperature	
7/ 9/18	Pump*	6,000	20,000	100+
9/13/18	Pump†	0	0	0
9/13/18	Pump‡	0	0	0
9/13/18	Pump§	1	0	0
9/18/18	Pump	0	0	0
9/30/18	Pump¶	4	6	0
10/ 1/18	Tap**	13	12	20
10/ 2/18	Tap††	2	1	0
10/ 8/18	Tap‡‡	50	600	100+
10/10/18	Tap‡‡	400	3,000	100+
10/10/18	Pump§§	1	4	0
10/12/18	Tap	5	0	0
10/27/18	Tap	1	11	0
11/ 1/18	Tap	7	9	0
11/ 8/18	Pump	1	2	0
11/15/18	Pump	3	20	0
11/23/18	Pump	0	1	0
12/10/18	Tap	1	6	0
12/18/18	Tap	0	17	0

* Before chlorination.

† Chlorination rate, 60 bubbles per minute.

‡ Chlorination rate, 42 bubbles per minute.

§ Chlorination rate, 24 bubbles per minute. This rate was subsequently used.

¶ Two new wells connected with the old one. Water slightly turbid at first.

** Storage tanks and pipes not flushed out.

†† Water pronounced potable.

‡‡ Chlorine solution valve in the suction line of the pump clogged, excluding chlorine.

§§ Valve cleaned.

of chlorinated lime, but if this had been done much closer supervision of the bags would have been necessary.

TABLE 4

Bacteriological data on typical wells

DATE	SERIAL NUMBER	COLONIES PER CUBIC CENTIMETER ON AGAR		GAS PRODUCERS PER 100 CC. IN LACTOSE BOUILLON
		37.5°C.	Room temperature	
7/ 5/18	3092	2,250	500,000	100+
9/20/18	8814	100	150	12
9/20/18	8815	17	60	25
9/20/18	8816	23	65	100+
9/20/18	8817	65	750	100+
10/23/18	12864	750	2,000	100+
11/29/18	17013	10,000	50,000	100+
12/10/18	18783	30	270	100+

Since water was of necessity being chlorinated by a large number of individuals, who had no special training for work of this sort, it was thought best to issue definite rules for the care of Lyster bags that would cover all cases. A copy of these rules follows:

HEADQUARTERS FIRST DEPOT DIVISION
OFFICE OF THE DIVISION SURGEON, A. E. F.

October 5, 1918.

Memorandum:

CHLORINATION OF DRINKING WATER

Break a tube of calcium hypochlorite into a clean ordnance cup.

Moisten the powder with a few drops of water and mix into a smooth paste.

Now fill the cup with water to within 1 inch of the top and mix thoroughly by stirring with a clean spoon.

Add this solution to a Lyster bag filled with clean water, stir thoroughly, *and allow to stand thirty minutes before using.*

Broken or cracked tubes must not be used.

One-half hour after a bag has been chlorinated withdraw a cupful of water and add to it a few drops of starch-iodide reagent. If a blue color is obtained, the water is ready for use. If no color is obtained, the water must not be used and the process must be repeated.

Calcium hypochlorite tubes and the starch reagent can be obtained at the Laboratory, Camp Hospital No. 26, or from the Sanitary Squads.

O. G. BROWN,
Colonel, Medical Corps,
Division Surgeon.

500.

It was found necessary to use the starch-iodide or ortho-tolidine test for free chlorine after a bag had been chlorinated, for two reasons. In the first place, exceptional waters might require more chlorine than that contained in one tube of chlorinated lime. In the second case it was found that a large percentage of tubes reached France in a broken or cracked condition, with the contents spoiled. A crack might be hardly perceptible but usually resulted in the chlorinated

TABLE 5

Bacteriological data on Lyster bags

DATE	SERIAL NUMBER	COLONIES PER CUBIC CENTIMETER ON AGAR		GAS PRODUCERS PER 100 CC. IN LACTOSE BOUILLON
		37.5°C.	Room temperature	
8/10/18	5397*	8,400	20,000	100+
8/22/18	6536*	30,000	50,000	100+
8/22/18	6537	1	2	0
8/22/18	6538	1	8	0
8/23/18	6686	1	2	0
8/23/18	6687*	2	40	100+
8/23/18	6688	1	2	0
8/31/18	7134	2	2	0
8/31/18	7136	2	1	0
8/31/18	7137	4	2	0
9/13/18	8217*	300	1,500	100+
9/14/18	8248†	25	3,000	0
9/20/18	8812*	3,000	5,000	12
9/20/18	8813*	6	10	12
9/26/18	9308*	320	650	25
9/30/18	9643*	850	1,250	100+
9/30/18	9646*	30	5	100+
9/30/18	9647*	110	75	100+
10/13/18	11,139	1	2	0

* Not chlorinated, chlorinated with spoiled tubes, or recontaminated.
† Sample taken more than 24 hours after chlorination.

lime in the tube becoming pasty. Unless properly instructed, men were liable to use such tubes and it was for this reason chiefly that a test for free chlorine was required for each bag before it was used.

In addition to the above precautions, occasional bacteriological samples were examined at the division laboratory.

A separate record was kept for each Lyster bag, from which it was possible to fix responsibility for the proper care of these bags. A copy of the blank form used follows:

RECORD OF WATER IN LYSTER BAG

FIRST DEPOT DIVISION

DATE	HOUR OF ADDING HYPOCHLORITE	BY WHOM CHLORINATED	HOUR OF TESTING	BY WHOM TESTED	RESULT OF TEST
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....

All water for drinking purposes was required to be chlorinated and all troops were ordered to drink only such water.

Stringent regulations of this sort were necessary, for it seems to be a characteristic of human nature that people will not believe in dangers that they cannot see. Moreover man is a lazy animal and usually has to be compelled to do things.

One rather striking illustration of the value of chlorination was obtained from a unit, the medical officer of which did not believe in the necessity for this precaution. In this unit Lyster bags were used merely as containers for water of bad quality with the result that a high percentage of the command suffered from diarrhoea. As soon as this condition was discovered steps were taken to compel the chlorination of the water used by the unit with the result that diarrhoea almost disappeared.

Tables 4 and 5 give some of the bacteriological results from wells in the area and on Lyster bags.

WATER SUPPLY AND SEWAGE DISPOSAL AT THE MILITARY AVIATION FIELDS, POSTS, DEPOTS, ETC., IN THE UNITED STATES[1]

By Captain Robert H. Craig

The Department of Military Aeronautics was responsible for the location, design and construction of its aviation fields and other posts from the beginning of the emergency until October, 1917, when this work was turned over to the Construction Division of the Army by order of the Secretary of War. Even after this date, the engineering section of the Department of Military Aeronautics governed in a large measure the design of utilities. Water supply and sewage disposal problems were handled somewhat differently than in the larger national army and national guard camps. The water supply problem was marked by the development of a large proportion of ground water supplies. Sewage treatment was marked by the fact that there was no standard unit adopted by the Department of Military Aeronautics as was done by the Army Cantonment Construction Division in its use of the Doten tank.

Civilian sanitary and civil engineers and architects were selected to design the water and sewage systems and as a result the types of design varied through a wide range.

Number and types of fields. There were established 32 regular flying fields and three balloon schools, in addition to several smaller fields which were in use only a short time. A number of general supply depots, repair depots, and miscellaneous posts were distributed throughout the United States, usually located where shipping facilities were readily accessible and within a fairly short shipping radius of the Flying Fields.

Selection of sites for flying fields. In the selection of sites for aviation fields the following qualifications for the location were considered, stated in the order of their approximate relative importance: (a) topography and soil conditions, (b) climatic conditions, (c) gen-

[1] Publication authorized by Surgeon General's Office, U. S. A. The author is an officer in the Sanitary Engineering Section of the Sanitary Corps, Medical Department, U. S. A.

eral health conditions, (d) location with respect to transportation facilities, (e) strategic location. This arrangement is somewhat different from that used in the selection of the site of a national army camp, national guard camp, etc., where general health conditions were the first consideration.

(a) Topography and soil conditions:—Aviation fields, under present flying conditions, must be located in the midst of a flat or almost flat country with a landing field that is nearly level so as to permit of easy rising and landing. The soil must be such that it drains readily and does not become excessively muddy, in order to permit the planes to rise from the ground readily and to prevent landing gear from becoming mired.

(b) Climatic conditions affect the aviation training to a greater degree than the training of infantry, artillery, etc. For the maximum efficiency in the training of aviation students the climate should be fairly warm or moderate, with little or no cold weather. There should be a minimum amount of rainfall, and wind conditions which are not extremely variable or subject to sudden change.

(c) General health conditions should be such that a safe, sufficient and potable supply of water is obtainable with reasonable expense; that sewage, garbage and other refuse can be disposed of with a minimum of cost and nuisance; that mosquitoes, flies and other insect pests are not present in sufficient numbers to interfere with good health or affect the comfort of the men, or where their breeding can be readily controlled; and that communicable disease is not excessively present.

(d) Transportation facilities should be such that food, materials of construction, planes, engines, etc., can be easily shipped to and from the field.

(e) Strategic position of fields in the United States covers such points as inland locations; location with respect to defense of seacoast; proximity to railroad centers, etc. In connection with requirements for the location of fields it is interesting to note their distribution and positions in the United States (table 1).

Expansion of fields in summer of 1918. In order to meet the requirements of the enlarged aviation program of the summer of 1918 it was necessary to increase the size and capacities of some of the water and sewage systems and plants. In general the water supply was adequate to meet the increased needs but some of the sewage treatment plants had to be augmented with new units or an addition to the old ones.

TABLE 1

Location of aviation fields showing their distribution throughout the United States

Southern States

Texas
Barron
Brooks
Call
Carruthers
Ellington
Kelly No. 1
Kelly No. 2
Love
Rich
Taliaferro
John Wise Balloon School

Florida
Carlstrom
Chapman
Dorr

Georgia
Souther

Alabama
Taylor

Mississippi
Payne

Louisiana
Gerstner

Arkansas
Eberts

Tennessee
Park

Oklahoma
Post

Northern States

Michigan
Selfridge

Illinois
Chanute
Scott

Ohio
Wilbur Wright
McCook

District of Columbia
Bolling

New York
Hazelhurst
Mitchell

Virginia
Langley
Lee Hall Balloon School

Far West

California
March
Mather
Rockwell
Arcadia Balloon School

WATER SUPPLY

After the location of the Flying Fields had been decided upon with reference to topography and weather, the water supply was selected with the following governing factors in mind.

Governing factors in selection of aviation water supplies.

(A) Quality of water:—The United States Public Health Service standard for the purity of drinking waters for interstate carriers,

which is the standard also adopted by the Medical Department of the army for waters used by the army, was the determining factor insofar as quality for drinking, washing, and bathing purposes was concerned in the selection of water supplies for the aviation fields.

(B) Quantity of water:—Water supplies were selected with a view to furnishing an abundant amount of water under adequate pressure for all the needs of the fields. The wisdom of this selection has been proved by the fact that the flying fields used larger unit quantities than the national army and national guard camps, although the reason for this larger consumption may have been partly due to some preventable causes. At no time were the aviation fields held down to using a fixed or limited quantity of water, this idea being in direct opposition to the policy of the Cantonment Construction Division of the army, which maintained that 55 gallons per capita per day was adequate. Table 2 appended shows the per capita water consumption at the various fields.

(C) Ease and efficiency of obtaining the supply:—

(a) Proximity to municipal or private supply:—Wherever a good municipal supply or a good private supply was available it was utilized, the water being secured by purchase from the municipality or company.

(b) Availability of ground water. Wherever it was possible to secure water from wells by drilling, this plan was adopted. Most of the fields were supplied from wells driven by the Government on the flying fields or in close proximity to them. The general success met with in securing a suitable water from ground water sources by well drilling was marked.

(c) Surface or impounded water supply which could be made suitable by treatment. It was found necessary to construct but one filter plant during the war period (Selfridge Field, Mt. Clemens, Mich.) although one other filtered water supply was developed later (Langley Field, Va.). Table 3 shows the types of supplies utilized.

Development of supplies. (A) Supplies from municipalities or private water companies:—Water purchased for the use of fields from municipalities or private water companies was delivered through lines leading from the nearest adequate sized water main to the camp distribution system. Frequently it was found necessary to raise the pressure in the camp mains by booster pumps installed at the camp, so that an adequate pressure was available for all purposes. Occasionally the water from outside sources was chlorinated at the

TABLE 2

Water consumption, sewage flow, etc., at aviation fields

AVIATION FIELDS	WATER	SEWAGE	PERCENTAGE RATIO OF SEWAGE FLOW TO WATER CONSUMPTION	TYPE OF WATER PIPE	REMARKS
	gals. per cap.	*gals. per cap.*			
Barron	98.0	99.0	101.0	Cast iron	
Bolling				Cast iron	
Brooks	245.0	274.0	108.0	Wood stave	Taken during low population
Call	66.5	66.5	100.0		
Carlstrom	74.0	65.5	84.4	Cast iron	
Carruthers				Wood stave	
Chanute	112.9	98.2	86.9	Cast iron	
Chapman				Cast iron	Ground water near surface
Dorr	65.5	64.0	97.3	Cast iron	
Eberts	142.0	156.0	110.0	Wood stave	
Ellington	125.0	114.0	91.0	Wood and cast iron	
Gerstner	112.0	144.0	128.0	Wood replaced with cast iron	
Hazelhurst				Cast iron	
Kelly No. 1	171.0	215.0	126.0	Wood stave	
Kelly No. 2	90.0	104.0	113.5	Wood stave	
Langley	83.0			Cast iron	
Love	125.0	124.0	99.2	Cast iron	
March	107.7	74.3	69.0	Wood stave	
Mather				Wood stave	
McCook				Cast iron	
Mitchell	42.0	70.0	166.6	Cast iron	High rate of ground water infiltration
Park	91.0	82.0	90.0	Cast iron	
Payne	86.0	69.8	81.0	Cast iron	
Post	66.0	63.0	95.0	Cast iron	
Rich	136.0	115.0	86.0	Cast iron	
Rockwell	101.0			Cast iron	
Scott	194.0	66.6	34.0	Cast iron	
Selfridge	100.0	61.0	60.5	Cast iron and wrought iron	
Souther	152.0	142.0	94.0	Cast iron	
Taliaferro	188.0	186.0	98.9	Cast iron	
Taylor		124.0		Cast iron	
Wilbur Wright	83.0	81.0	97.0	Cast iron	

TABLE 2—*Concluded*

Balloon schools

AVIATION FIELDS	WATER	SEWAGE	PERCENTAGE RATIO OF SEWAGE FLOW TO WATER CONSUMPTION	TYPE OF WATER PIPE	REMARKS
	gals. per cap.	*gals. per cap.*			
Arcadia.....					
Lee Hall.....				Wood stave	
John Wise.....		139.0		Cast iron	

* Some of these flows were taken after the armistice-signing date when camp populations were lower than normal.

camp even though in some instances it had been already chlorinated at the source.

B. Well supplies (government developed):—There is a similarity in the development of the well water supplies due to the governing policy of the building and grounds section of the Department of Military Aeronautics.

General plan of development:—Wells were drilled, cased, the water raised to the ground elevation into wooden storage tanks by airlift pumps, boosted to an elevated steel tank on a 135-foot tower by a centrifugal pump, gasoline engine or electric motor driven, from which tower the water was distributed through cast iron or wooden mains by gravity to the several points of the field. There were various departures at some of the fields, such as the use of centrifugal well pumps, concrete ground elevation storage tanks, direct pumping to the distribution system with the elevated tank acting as an equalizing reservoir, but the general plan outlined above was ordinarily used. The centrifugal pumps were always connected so that they could be made available for fire fighting purposes instantly.

(C) Filtered water supplies (government developed):—The two filtered water supplies developed did not differ from standard mechanical filter plant design. The water was coagulated with aluminum sulphate, sedimentated, filtered through rapid sand gravity filters and chlorinated.

Chlorination. Necessity for chlorination of well supplies:—Table 3 shows the number of well supplies which were reported as showing

TABLE 3

Water supplies at aviation fields, showing type of supply, agency furnishing water, disinfection

FIELD	AGENCY SUPPLYING WATER	TYPE OF SUPPLY	DISINFECTION. CHLORINE CONTROLLED BY	B. COLI IN WELL WATER
		Municipal and private sources		
Bolling	District of Columbia	Filtered river water		
Brooks	San Antonio Water Supply Co.	Deep well		No
Call	Wichita Falls Water Co.	Filtered lake water	Hypochlorite at filter plant. At field manual solution feed	
Chanute	Rantoul Municipal Water Works	Deep well		
Hazelhurst	Garden City Water Co.	Shallow wells		
Langley	Newport News Water Co. Government built own treatment plant after armistice	Impounded and filtered surface water	Manual direct	
Love	City of Dallas and government	Deep well	Manual solution feed for camp well	Yes
Post	City of Lawton, Oklahoma	Impounding lake, small filters at field	Manual direct	Organisms giving all presumptive tests but not confirmed B. coli.
Rich	City of Waco, Texas	Mixed well water and filtered river	Manual solution and manual direct	Yes; in smaller group of wells
Rockwell	Coronado Water Company, Cal.	Deep and shallow well		No
Scott	East St. Louis and	Filtered river	Chlorinated	

Scott	East St. Louis and Interurban Water Co.	Filtered river	Chlorinated	
Arcadia Balloon School	City of Arcadia	Deep wells		No
Lee Hall Balloon School	Part private owned; part government	Deep wells	Chlorinated	Suspicious organisms
John Wise Balloon School	San Antonio Water Supply Co.	Deep wells		No
		Government		
Barron	Government	Deep well	Manual solution	Yes
Carlstrom	Government	Deep well	Manual solution	Yes
Carruthers	Government	Deep well	Manual solution	
Chapman	Government	Deep well		
Dorr	Government	Deep well	Manual solution	Yes
Eberts	Government	Deep well		Water sometimes cloudy, no B. coli
Ellington	Government	Deep well		
Gerstner	Government	Deep well	Manual solution	Yes
Kelly No. 1	Government	Deep well		
Kelly No. 2	Government	Deep well		B. coli eliminated by repairing casing
March	Government	Deep well		
Mather	Government	Deep well		
Mitchell	Government	Deep well		No
Park	Government	Deep well		No
Payne	Government		Manual solution	
Selfridge	Government	Filtered lake	Manual solution	
Souther	Government	Deep well	Manual solution	High 37.5° Nut. Agar counts but no B. coli
Taliaferro	Government	Deep well	Manual solution	No
Taylor	Government	Deep well		No
Wilbur Wright	Government	Deep well	Chlorinated but later discontinued	

organisms of the B. coli group. In one or two cases this contamination was due to defective well casings. In some of the remaining cases unconfirmed presumptive tests were reported as B. coli, but in most instances B. coli did actually appear. The Aviation Medical and Engineering Departments considered that it was always better to be far on the side of safety by using chlorine than to take time for extended tests and analyses which might prove its use unnecessary.

Liquid chlorine was used in practically all instances where disinfection was thought necessary, except that hypochlorite of lime was used during times of breakdown of the chlorine apparatus or periods of waiting for arrival of chlorine cylinders. Platform beam scales were used in the majority of installations to keep a constant check on the operation of the chlorine apparatus used. The necessity for skilled operation of these chlorine feed machines was apparent and sufficient repair parts were not usually kept on hand, so that when a machine needed repairs it was often necessary to keep it out of service for a month or so before the proper parts arrived.

Responsibility for quality of water. At all the fields the Medical Department is responsible for the health of the troops. The post sanitary inspector was usually detailed by the post surgeon to supervise or inspect the operation of the water system and to guard against any possibility of contamination of the supply. Sanitary engineers from the Sanitary Corps of the army were assigned to duty at some of the fields to advise in the operation of the water supply purification plant systems, sewage treatment plants, methods of mosquito control, etc., and in such cases intelligent operation of plants usually resulted.

Laboratory control. Few of the laboratories at the post hospitals were equipped with complete facilities for conducting bacterial and chemical analysis. As a result the Medical Department laboratories in the several army zones, the Public Health Service laboratories, and municipal and private laboratories were utilized for this purpose. Samples were collected and shipped for analysis infrequently and irregularly and in most cases the samples shipped were not iced and were on the road for one or two days, causing results of analysis that were not a true index of the quality of the water at the time of collecting the sample.

Operation of water systems. In the early history of the development of the water supply systems and sewage treatment systems at the aviation fields and depots, it was the policy of the Aviation Section

to have the Government superintendent of construction take over the operation of the systems after they were completed. Later this policy was changed and maintenance officers were appointed at each post by the commanding officer of the post. The duties of this officer included responsibility for the maintenance and operation of the water supply system, sewerage and sewage treatment, electric lighting and heating; also maintenance and repair of roads, pavements and buildings, etc. The maintenance officer reported to the building and grounds section, air service property division of the Department of Military Aeronautics, through military channels. This section ordered needed equipment or materials for changes in construction and dictated general policies in methods of operation. At some fields, as mentioned above, sanitary engineers of the Sanitary Corps, Medical Department, who were assigned to the fields,to advise on the operation of water purification and sewage treatment plants, actually operated these utilities for the Maintenance Departments.

SEWAGE COLLECTION, TREATMENT, AND DISPOSAL

Collecting systems. Every aviation field and balloon school was equipped with a water carriage sanitary sewer system. At no field was there a combined system, although several were equipped with complete storm water systems in addition to the sanitary sewers. The design of sewers and the materials used in their construction did not vary from standard sewer practice.

Grease. The problem of the collection of grease received much attention and gave much trouble. In the original design of the field sewer systems, small cast iron sink traps were used, these being usually augmented by an outside trap, of vitrified clay pipe or cast iron. Because of the large quantities of water used in the camp kitchens together with the high temperatures at which the water was wasted, coupled with the small size and capacity of the traps, little opportunity was afforded for the cooling of the water and the separation of the grease. The result was that most of the grease passed to the sewage treatment plant. In the summer of 1918 large concrete traps similar in design to the type of trap adopted by the Construction Division for the national army and national guard camps were installed for experimental purposes on some of the camp outfall sewer lines leading to the treatment plants. Because of the collection of the floating fecal matter with the grease, these were soon found impracticable. The

type of large concrete trap adopted by the Construction Division to collect grease from a row of kitchens is practical and effects a high ratio of grease collection but means must be provided for frequent removal of the organic matter, such as corn, peas, etc., which gathers rapidly at the bottom of the trap. Bacterial decomposition and putrefaction soon set in with their resultant odors if this removal is not accomplished frequently. Grease was disposed of either by burning or by selling it along with the garbage.

Quality of sewage reaching sewage treatment plants. The sewage upon its arrival at the sewage treatment plant is ordinarily a weak, fresh sewage with the suspended matter in an uncomminuted state, and with a grease content relatively high as compared with average municipal sewage but on the average somewhat lower than that of the national army camp sewage. Table 4 shows the chemical analyses of raw sewage at four typical camps.

Quantity of sewage flow. Per capita sewage flows are given in table 2. The per capita flow is much higher than for national army and national guard camps. The hourly ratio varies widely, the highest rates ordinarily occurring between six and nine o'clock in the morning and at the same hours in the evening. From midnight to six in the morning the flow is at a minimum, becoming almost nothing at some of the fields.

Design of sewage treatment plants. It did not appear necessary to provide sewage screens and detritus chambers except where they were to precede the pumping units. Imhoff tanks were installed at 18 of the 30 sewage treatment plants and at the remaining 12 plants septic tanks were put in. Many of the Imhoff tanks were covered with screens which greatly aided in reducing the fly menace. At only one field was the Doten or Construction Division tank installed, at the Arcadia Balloon School, Cal.

In the summer of 1918 the engineering section, supply division of the Department of Military Aeronautics, formulated the following general rules for the design of sewage treatment plants:

Imhoff Tanks. (a) Sedimentation chamber: flow, 87 gallons per capita; flow takes place in 16.5 hours; normal detention period, 2 hours. (b) Sludge digestion chamber: 0.102 cubic yard per person.

Septic tanks. Normal detention period, 8 hours.

Filters. (a) Sand filters: 1200 persons per acre installed. (b) Sprinkling filters: 200,000 gallons per acre per foot effective filter depth. At 87 gallons per capita per day this equals 2300 persons per acre per foot effective filter

TABLE 4

Chemical composition of raw sewage, Imhoff effluent, and sprinkling and sand filter effluent at four aviation fields. Results in parts per million

	KELLY 1 (JANUARY, 1919)			KELLY 2 (FEBRUARY, 1919)			TALIAFERRO (AVERAGE FOR MAY, 1918)			CARLSTROM (JUNE, 1918)	
	Untreated	Imhoff effluent	Sprinkling effluent	Untreated	Imhoff effluent	Sprinkling effluent	Untreated	Imhoff effluent	Intermittent sand filter effluent	Untreated	Imhoff effluent
Total solids	649.0	457.0	439.0	636.0	536.0	564.0				895.0	694.0
Suspended solids	269.0	69.0	38.0	178.0	48.0	48.0	342.0	146.0	58.0	155.0	194.0
Volatile solids										491.0	421.0
Fixed residue										404.0	263.0
Nitrogen as free ammonia	10.0	13.0	3.0	13.0	18.0	9.0	43.0	5.0	2.3	23.8	28.6
Nitrogen as nitrites	0.02	0.03	0.45	trace	0	2.2	0.011	0.003	1.7		
Nitrogen as nitrates	0.2	0.09	9.3	0.5	0.4		0.69	0.31	2.78		
Oxygen consumed*	83.0	47.0	14.0	92.0	55.0	46.0	200.0	133.0	59.0		
R. O. C	186.0	97.0	21.0	143.0	101.0	14.0					
Ether soluble (acid)	22.5	19.0	2.6	20.0	5.2	5.6	132.0	55.0	10.0	156.4	33.2
Ether soluble (not acid)	22.8	20.0	2.4	15.4	4.8	5.0				125.6	25.2

* Recommended method, "Standard Methods of Water Analysis," A. P. H. A., 1917.

depth. (c) Contact beds: 70,000 gallons per acre per foot effective depth. At 87 gallons per capita per day this equals 800 persons per acre per foot.

Other things being equal, we recommend the adoption of Imhoff tanks and sprinkling filters, with subsequent chlorination if deemed necessary.

Regarding per capita flow: We quote 87 gallons as being the minimum. However, if it is known that the per capita daily flow will be more than this it should be determined as nearly as possible and be made amply large.

Minimum grades for sewers are quoted:

Size of pipe	*Grade in feet per 100*
6 inches	0.6
8 inches	0.4
10 inches	0.3
12 inches	0.22

Imhoff tanks versus septic tanks. At the aviation fields the problem of the relative expense of the Imhoff tank and the Doten septic tank was not seriously considered, with the result that a majority of the plants were equipped with Imhoff tanks. In general the Imhoff tank gave a higher degree of clarification than the plain septic tank and turned out a better digested sludge.

Imhoff tanks embracing the following features gave the best results: (a) Longitudinal flow; (b) but one flowing-through or settling compartment over each sludge digestion chamber; (c) settling compartment with steep sloping sides, not less than 1: 1; (d) with sufficient overlap of sides of settling compartment at slots to insure the complete deflection of the rising gas to the gas vents; (e) with retention period in the settling compartment of between 2 and 3.5 hours; (f) with sludge storage capacity sufficient to insure at least 6 months storage; (g) with gas vent area from 20 to 25 per cent of total tank area.

The relative efficiency of deep and shallow sludge digestion compartments was not determined, although shallow tanks with large sludge digestion capacity have operated as satisfactorily as the deeper ones.

Construction of plants. The sewage treatment plants were constructed by private contractors, the contract being let by the Department of Military Aeronautics, which department employed a civilian inspector to check up construction work. In general, construction was of good quality, performed satisfactorily.

Operation of sewage treatment plants. As mentioned in the paragraph on operation of water systems, the maintenance officer was in charge of the utilities, which included sewage treatment plants. The

Engineering Section of the Supply Division sent out to each camp, in the fall of 1918, a set of "Instructions for the Operation of Sewage Disposal Plants at Aviation Schools." This paper included recommendations for the operation of Imhoff tanks, septic tanks, sprinkling or trickling filters, sand filters, contact beds, screens and chlorine dosage apparatus. It also included directions in regard to measurement of sewage flow and methods of sampling and testing sewage.

Instructions of this kind can be given in great detail and will undoubtedly aid in the proper operation of the plant, but the successful operation of any sewage treatment plant will always depend, in the final analysis, on the intelligent care and control of a skilled operator. It may not be necessary to have this skilled operator in immediate control of the plant operation but he must give constant advice and regular attendance. The engineering section commissioned one such man to travel from plant to plant, making recommendations on plant operation and also making chemical and bacterial analyses of the sewage. The territory covered was necessarily limited because of the time required but the many advantages obtained from the use of this man were apparent.

Laboratory control of sewage plant operation was similar to the conditions mentioned with reference to water supply.

RÉSUMÉ

In general, the water furnished to the aviation fields was of an excellent quality, conforming to the standards of bacterial purity of the Treasury Department for interstate carriers. It was potable and not excessively hard. The quantity was abundant and was enough for all the essential needs of the posts in addition to the non-essential needs, such as the sprinkling of roads and lawns, lavish use of water for bathing, etc. This water was furnished under adequate pressure with sufficient reserve equipment for fire pressures.

The necessity for close laboratory control of water supplies and sewage treatment systems is self-evident and axiomatic. The more general use of correct methods of collection, shipping and analyzing samples is essential.

The use of wood stave pipe did not prove generally satisfactory, although in some cases this was due to the use of greater water pressure than the pipe had been designed for, together with the none too careful laying of the pipe.

The use of chlorine was general, for out of the 20 Government-developed water supplies 10 were chlorinated, and 20 of the 30 sewage treatment plants used chlorine for disinfection of the treatment plant effluent. The flow of chlorine gas, where liquid chlorine was used, was regulated in all but three or four cases by manual control machines. It appears to be better practice at a plant with intermittent sewage discharge due to the use of intermittent filtration units to use a manual control chlorinator resulting in overdosing the sewage at times of low flow, rather than to experience the difficulty with an automatic control chlorinator in dosing widely varying rates of flow. The necessity of intelligent supervision and skillful operation of chlorine machines cannot be overemphasized, as chlorine apparatus is by no means fool-proof.

The average per capita sewage flow at the fields was high, resulting in a weak sewage, and the comparatively simple sewer systems resulted in a raw sewage which was fresh and uncomminuted.

Sewage plant effluents were generally of as good a quality as the water of the streams into which they were discharged.

The grease problem was a real one and had not been successfully solved at the time of the signing of the armistice and not much has been accomplished since.

The outstanding feature of aviation water supplies and sewage disposal systems is the need for skilled operators. A skilled intelligent operator, whether he be the plant attendant or an advisory engineer, chemist or operator, who can make occasional inspections, can often obtain excellent operating results from a poorly designed plant and certainly can do so from a well designed one.

REPORT OF COMMITTEE ON PRIVATE FIRE PROTECTION SERVICE[1]

Introduction

Private fire protection service has been a subject of discussion between the water purveyor and the insurance interests for years. The *Proceedings* of both the American and New England Water Works Associations contain many pages devoted to this topic, and the interest displayed is evidence of the concern which this class of service has caused the water works superintendent. A number of different questions are involved which divide themselves naturally into two classes, physical and fiscal. The physical questions relate to the manner of installation, the fiscal questions to the distribution of the cost of installation and proper charges for service. The more important questions may be enumerated as follows:

A. *Physical:*

(1) Shall water for domestic and manufacturing uses be furnished through the same service pipe with water for private fire protection equipment?

(2) How shall the water purveyor be protected so as to prevent the intentional or unintentional use or waste of water through such connections?

(3) How shall private fire service pipes be controlled where they enter buildings or private property so that in case of the breaking of the inside pipe, or of the service pipe, water may be shut off and bleeding of the water system prevented?

(4) What limit should be placed upon the size of fire service connections?

(5) What means shall be adopted to prevent the pollution of a public water supply through a private fire protection service when an independent water system is also connected with the fire protection system?

[1] Presented at the Buffalo Convention, June 10, 1919. Written discussions are requested and should be sent to the Editor.

B. Fiscal:

(6) By whom should the cost of installing the private fire protection service and accessories be borne?
(7) Should a charge be made for private fire protection service?
(8) How should the charge for private fire protection service be determined?

Other and collateral questions suggest themselves, but your committee will confine itself to the more important ones above enumerated.

A. Physical Questions

Definitions. Before discussing the questions outlined above it may be well to ask what is meant by private fire protection service. So far as the water purveyor is concerned, it may be defined as furnishing water for an individual, firm or corporation for special fire protection, in addition to that furnished by the water purveyor through the hydrants placed upon the public streets. A private fire service is a connection from a public water system to carry water to fire fighting equipment on the property of a property owner. Such a connection may supply water conjointly for the fire protection equipment and for domestic, commercial and manufacturing purposes, or for the fire protection equipment of a premise alone. A private fire protection system usually includes a system of pipes in buildings or yards, or both, to which automatic or open sprinklers, standpipes for hose connections inside the building, or fire hydrants in the yard for outside protection are connected. The private fire protection service may be direct from the city mains through the service connection to the private fire protection equipment where the pressure on the public water system is sufficient for fire protection purposes, or the service may be indirect through a private fire service connection discharging into a cistern or tank from which a pump suction is connected with fire pumps which maintain adequate fire pressures within the protected property. A *supplementary* supply for private fire protection may be maintained by the installation of elevated tanks within the protected property designed to supplement the public supply in the event of fire. Private fire protection service may be wholly supplied from the public system, or it may be supplemented by an *independent* supply owned or maintained by the protected property.

So far as the water purveyor is concerned, the problem is the same, whatever the arrangement inside the property lines, except that where an independent supply supplements the public supply, the water purveyor must take precautions to prevent the possible pollution of the public supply from an impure independent supply, particularly if the pressure carried on the independent supply is greater than that on the public supply.

The ordinary private fire service equipment may consist of some or all of the following elements:

a. Automatic sprinklers.

b. Open sprinklers turned on by hand for the outside protection of cornices and windows.

c. Standpipes for hose in buildings.

d. Yard hydrants.

e. Connections for filling cisterns or tanks from which fire pumps draw, or direct connections to the suction connections to fire pumps.

f. Elevated tanks for the storage of a supply of water to be used for fire protection purposes only.

(1) SHALL WATER FOR DOMESTIC AND MANUFACTURING USES BE FURNISHED THROUGH THE SAME SERVICE PIPE WITH WATER FOR PRIVATE FIRE PROTECTION DEVICES?

From the insurance viewpoint, a separate connection for fire protection prevents robbing the fire protection equipment by other uses. It reduces the formation of sediment or corrosion in important fire mains. It reduces the possible interruption of the fire service due to the breakage of domestic or commercial connections about the protected property. It eliminates subjecting the ordinary piping system to fire pressures if fire pressures are raised through the instrumentality of a fire pump on the premises, and it makes the control of the fire protection system simpler. From the viewpoint of the water purveyor, it also makes control of the fire protection system simpler. It tends to prevent improper use of water from private fire systems. It reduces the liability of supplying polluted water to the occupants of the protected property where an independent source of doubtful purity is connected with the fire protection equipment. Furthermore, the use of a separate service pipe connection for fire protection removes the necessity for the accurate commercial measurement of all the water supplied through the fire service pipe.

On the other hand, it is not always feasible or advisable for the water purveyor to insist upon separate fire service connections. They should be required for large factories, mills, industrial plants, railroad terminals and the like, but in buildings or plants such as storage warehouses, office buildings, hotels, apartment houses, theatres, public buildings and schools, where fire pumps are not a part of the equipment and no independent source of supply is connected with the fire service equipment, a single service connection to supply both fire service requirements and the ordinary daily consumption may be found satisfactory, provided a meter which accurately records all rates of flow from the least to the greatest is installed on the service connection. If the water purveyor is not able to compel the use of such a meter, then the combined use of a single service connection for both fire and general uses is unfeasible and impracticable and it becomes necessary to insist upon a separate connection for fire service. In general, then, it is advisable to install separate fire service connections for all mills, factories, industrial plants, railroad terminals and the like and to insist upon separate connections for all classes of property unless it is feasible to install a meter which is as accurate as one designed for the registration of domestic or commercial consumption. It is inadvisable in any case to allow the combined use of a single service connection, when protected by fire service meters only or by other methods which are practical on service connections used for fire service alone. In no case should combined service connections be allowed for premises supplied from an independent water supply for fire protection.

(2) HOW SHALL THE WATER PURVEYOR BE PROTECTED SO AS TO PREVENT THE INTENTIONAL OR UNINTENTIONAL USE OR WASTE OF WATER THROUGH SUCH CONNECTIONS?

The recorded instances of intentional or unintentional use of water through unmetered fire protection services, as well as loss of water due to leaks in the piping system within the property lines of protected properties, are too numerous to be ignored. Your Committee sent out nine hundred letters to the membership of the American Water Works Association and requested them to furnish information with relation to their experience in this respect. Five hundred and twenty-one replies were received, two hundred and

thirty-six of these testifying to actual experience of the intentional or unintentional use or waste of water through unmetered fire connections. Your Committee has not considered it advisable to publish these letters so as to connect the reported cases of the improper use or waste of water through fire connection services with either the party furnishing the information or the parties violating the fire service agreement. (Appendix 1.)

The replies received indicate very clearly that there are very few water works which maintain a systematic and comprehensive supervision of the distribution of water which have not discovered waste or the use of water for other than fire protection purposes on premises where water is obtained through private fire service connections. In many instances, the amount of water so wasted or obtained is very large and the consequent loss of revenue, based on the established rates for water, so great as to produce a serious loss of earnings.

It may be well to point out in this connection that possibly too much emphasis has heretofore been placed upon the intentional or unintentional use of water through unmetered fire service connections and too little emphasis upon the liability of waste, in large plants especially. In the absence of any check on the waste through pipe lines in private property there is no incentive for the property owner to prevent it. The experience of all water works men with relation to waste on unmetered domestic connections is sufficient to remove all doubt of the accuracy of this observation.

Laying aside the injustice done to the water purveyor, the water works which permits a situation to exist wherein water can be obtained by certain parties for nothing is guilty of a discrimination against all of the others who take their service. Every loss sustained through the intentional or unintentional use of water or waste of water through private fire service connections imposes an unfair burden upon the other water takers and, therefore, it is in the interests of the community at large either to prevent those who install private fire service connections from using water for other than fire purposes, or else to secure a revenue commensurate with the water consumed and thereby to lessen the burden of the great majority of water takers.

The installation of a meter adds nothing to the value of fire protection service from the consumers' viewpoint. On the contrary, it adds to the cost of private fire protection service and, there-

fore, the underwriters and the individuals, firms or corporations installing private fire protection service equipment have opposed the use of meters. Many of the ordinary types of domestic and commercial meters are objected to by the underwriters on the ground that the moving parts may become clogged and obstruct the flow of water. Some of the ordinary types of domestic and commercial meters create large friction losses when delivering the quantities necessary for fire protection service. Fish traps are also objected to because they may become clogged. Several meters designed especially for fire service connections have been developed which eliminate in large measure the objection raised to the ordinary domestic and commercial type of meter. Among such may be mentioned the Hersey Detector Meter sold by the Hersey Manufacturing Company, the Trident Protectus meter, manufactured by the Neptune Meter Company, and the Utility Meter furnished by the Pittsburgh Meter Company. These Meters differ chiefly in details. In principle they are the same. They consist of a check valve in the main supply line, arranged with a bypass on which a meter is installed to measure accurately all water passing through the bypass around the check, together with another meter which measures the quantity of water which passes through the check valve when the valve is open.

Owing to the custom in some cities of furnishing water for fire protection and for purposes other than fire portection through the same service connection, a demand has been created for a device which will satisfy the requirements of the underwriters with regard to unobstructed flow and which, at the same time, will measure all flows with substantially commercial accuracy. The creation of a meter which will register all flows with substantial accuracy without causing obstruction is extremely difficult, and your Committee is of the opinion that the demand for such a meter is not based on reasonable requirements for private fire protection service. However this may be, the chance of obstructing the flow has been practically eliminated by the design of special meters for private fire protection service, but notwithstanding this fact the underwriters claim that the probability of shutoff due to the repairs and adjustments required on fire protection meters is not to be overlooked. For this reason they have insisted upon the introduction of a bypass around fire protection service meters so that water for fire service may be obtained when the meter

is being examined, adjusted or repaired. It is true that the valve on the bypass is sealed so that water may not be used ostensibly through the bypass unless the seal is broken, but the installation of this bypass results in the practical elimination of the security to be obtained from the installation of the meter as a preventive against the intentional use of water through private fire service connections in the absence of systematic and regular inspections. It is interesting to note in this connection that the insurance interests install alarm valves in their fire service lines without the installation of a bypass and also that in the interests of economy they recommend the use of fire service meters of a size smaller than the fire service connection. Your Committee sees no good reason for requiring a bypass around these meters in such circumstances.

It is not the intention of your Committee to dwell upon the unnecessary restrictions which the underwriters have placed upon the measuring of water on private fire service connections, but all of these complications have resulted in increasing the cost of providing private fire service installations, which is objectionable both to the underwriter who desires that every inducement should be given to the installation of private fire service devices, and to the property owner who desires to obtain such protection at a minimum of cost. From the water purveyor's viewpoint every inducement should be offered to the introduction of private fire service systems, or, for that matter, for the installation of any device which tends to reduce the economic loss by fire, as a reduction of such loss is a benefit to the entire community. For many years there has been a growing realization of the added security of life which comes from automatic sprinkler protection. This should not be forgotten. The water utilities, on the other hand, encounter so many instances of the abuse of private fire service connections that it is incumbent upon them to protect themselves against such abuse. The water actually used for the extinguishment of fires or for testing fire equipment is so small as to merit no consideration, and the water purveyor is more than willing to furnish such water without a specific charge. The installation of the meter on a strictly fire service connection is, therefore, solely for the purpose of preventing abuse. A typical layout for a private fire protection service as now installed is illustrated in figure 1.

The studies of your Committee leave no doubt that the sentiment of the great majority of the water works superintendents is

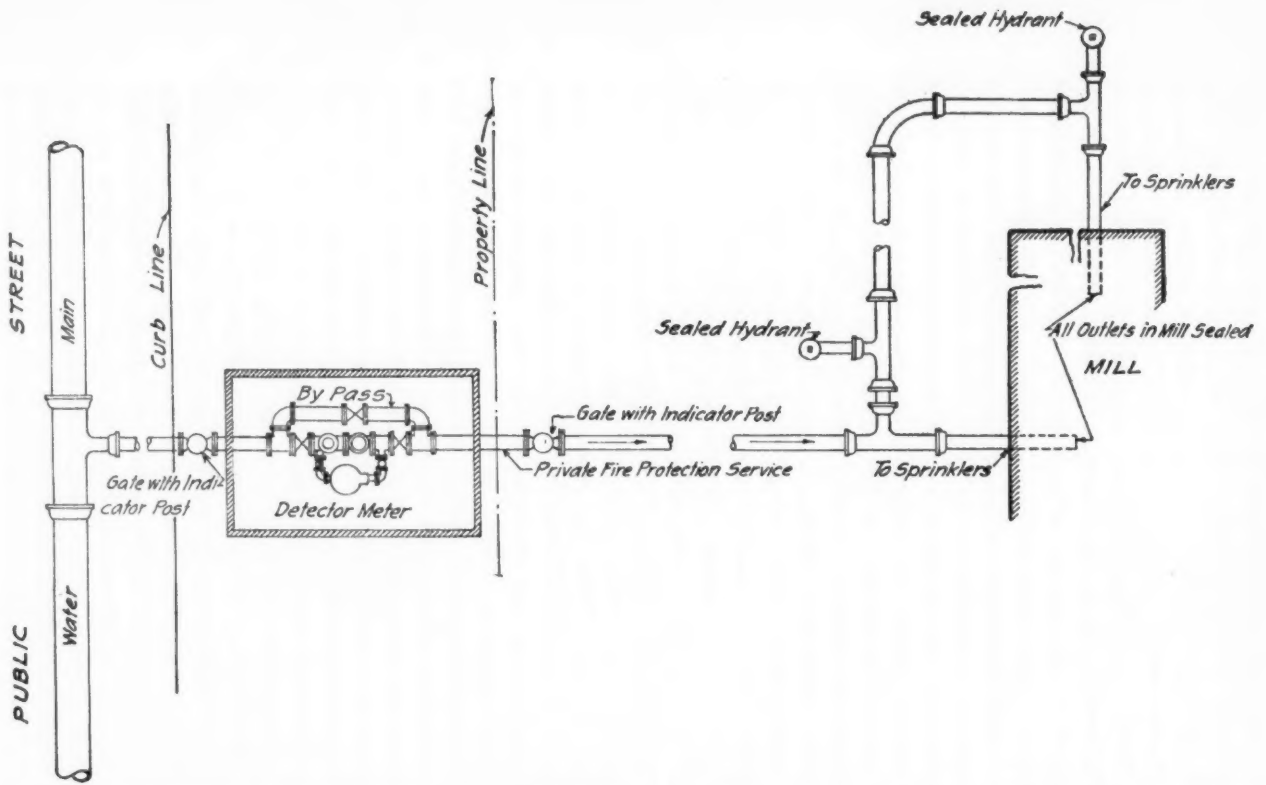


FIG. 1. ARRANGEMENT OF SERVICE PIPE UNDER THE METER SYSTEM OF PREVENTING WASTE AND SURREPTITIOUS USE OF WATER THROUGH SUCH SERVICES

Condition: (1) Building a safe distance from the main in the street. (2) Separate services are used for fire and manufacturing purposes. (3) The sprinkler system is supplied only by the public water supply, there being no independent water supply, or there being no physical connection between independent water supply and the public water supply.

in favor of the introduction of meters on private fire service connections unless some other adequate means of protecting the water utility can be devised. Your Committee feels that this position is entirely justified by its investigations. It may be possible, however, where separate fire connections for fire protection only are installed, to safeguard the water supply without the use of meters, and your Committee offers for consideration what it has termed for convenience the "Bond-Alarm-Inspection System."

Our studies have led us to the inevitable conclusion that whether meters are installed or not, the up-to-date water works must hereafter maintain a regular and systematic inspection of private fire service connections and equipment. The mere installation of a meter of the fire service type is not sufficient. Such devices must be regularly looked after. In the large plants this inspection system may call for detailing one man or a special corps of men to this particular work. In the smaller systems, some one man may be chosen whose duty it will be to make periodic inspections of private fire service connections and equipment. If this is done, we suggest that the installation of the expensive fire service meters may be obviated and the water purveyor sufficiently protected in the following way:

First. Require that this equipment shall be installed on fire service connections used solely for fire protection service.

Second. Require the applicant for such a connection to file a bond with the water purveyor with satisfactory sureties, the bond to be conditioned upon the use of the fire service connection for fire protection only and to be forfeited in the event of a violation of the rules under which the connection is given or of the abuse of the service through the taking of water for purposes other than fire protection either intentionally or unintentionally or through wastage. The amount of this bond should be fixed in amount sufficient to make penalty paid for infraction of rules or abuse sufficiently heavy to deter the water taker from running any risk in the matter.

Third. Install an alarm valve equipped with a pressure recording gauge and a small bypass meter, as indicated in figure 2.

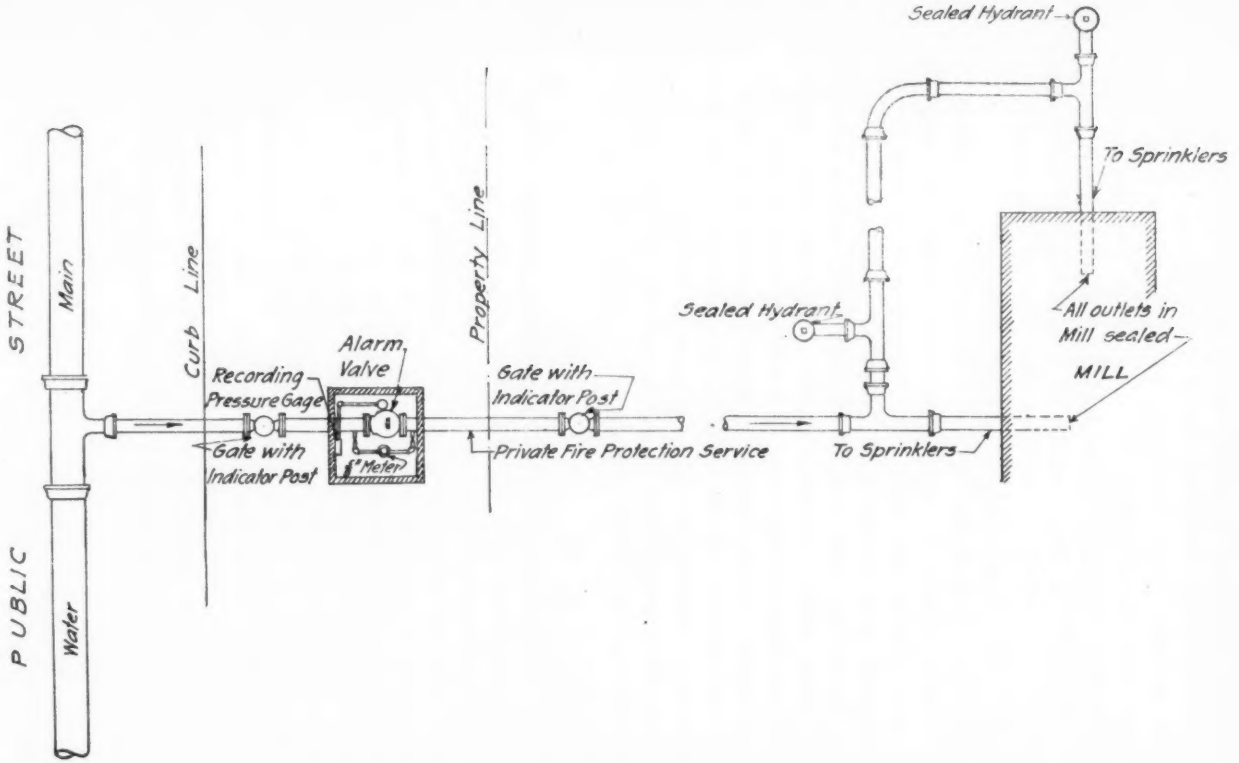


FIG. 2. ARRANGEMENT OF SERVICE PIPE UNDER THE BOND-ALARM-INSPECTION SYSTEM OF PREVENTING WASTE AND SURREPTITIOUS USE OF WATER THROUGH SUCH SERVICES

Condition: (1) Building a safe distance from the main street. (2) Separate services are used for fire and for manufacturing purposes. (3) The sprinkler system is supplied only by the public water supply, there being no independent water supply, or there being no physical connection between an independent water supply and the public water supply. (4) Regular and systematic inspection of alarm valve, etc., is maintained.

Fourth. Seal all yard hydrants, valves on hose outlets on stand-pipes, and other outlets connected with the sprinkler system.

Fifth. Arrange for systematic weekly inspection of the alarm valves and monthly inspections of all seals on hydrants, standpipes and sprinkler system valves.

An alarm valve is nothing more than a check valve arranged with a clapper which, when raised a slight distance from its seat, opens a port which is connected with a small pipe on the outside. This small pipe connects with a hydraulically operated circuit closer, which in turn operates an alarm bell. The circuit closer is operated by the water pressure in the service pipe which is transmitted to the circuit closer through the small pipe when the clapper rises from its seat. For insurance purposes the purpose of the alarm valve is to notify the property owners of an incipient fire, for when the circuit closer is thrown the alarm rings. These alarm valves are usually so designed that when one sprinkler head opens the clapper rises from the seat sufficiently to open the port in the seat. The discharge from one sprinkler head is about 20 gallons of water per minute, so that every time water passes through the alarm valve at a rate of approximately 20 gallons per minute the alarm will ring. If an eight-day recording pressure gauge were connected with the port in the valve seat as well as the alarm bell, it would register simultaneously with the ringing of the gong, and the inspectors of the water department could, during their weekly inspections, observe the dates and times when the clapper of the valve lifted from its seat. These records could be removed and filed in the archives of the water department and would serve, not only as a record of the use of water through the fire service connection, but also a check upon the inspectors who would be required to file them. If, in addition to the recording gauge, a small $\frac{5}{8}$-inch meter were installed on a bypass around the alarm valve, small flows, insufficient to register on the recording gauge, would be accounted for by the meter.

For insurance purposes these valves are usually placed within the property, but there is no reason why they should not be placed on the service connection and an alarm gong placed on the outside of the building so that an alarm would be given when water in excess of 20 gallons per minute was used for other than fire pur-

poses. The property owner would thereby be notified that something was wrong. Such an installation would serve the dual purpose of fulfilling insurance requirements and the requirements of the water utility. Insurance companies do not require bypasses around alarm valves when placed on the sprinkler system, and so there is no reason why they should require them when placed on the service connection. This combination of devices, while cheaper, functions in substantially the same way as the ordinary fire service meter, which in its essential parts is nothing more than a check valve with a bypass meter. An illustration of an equipment of this kind is given in figure 3.

The value of a water flow alarm valve attached to an automatic sprinkler system cannot be overestimated. The records show that sprinklers alone fail to extinguish one-third of all fires occurring in buildings with sprinkler protection, and in such cases the water flow alarm performs the important function of promptly summoning help to the scene of the fire. The signal from a water flow alarm may be the first notification to persons of a fire in the building and be instrumental in causing a prompt exit of those not delegated to the duty of fire fighting. In those cases where sprinklers succeed in extinguishing fires, it is necessary that notification of the flowing water be given in order that valves may be shut and unnecessary water damage avoided. The flow valve alarm also serves to notify the proper parties if a sprinkler head is broken, if a sprinkler pipe freezes and bursts, or if water is wasted for any other reason.

From the insurance viewpoint or from the viewpoint of the owner who wishes to avoid water damage and loss, against which he commonly carries sprinkler leakage insurance, the ordinary form of fire service meter furnishes no additional protection. If a fire service meter is installed on the fire service connection, therefore, an alarm valve equipment should also be installed. By utilizing the alarm valve as a protection, not alone to the insurance interests and the property owner, but to the water purveyor as well, a saving substantially equal to the cost of the installation of the meter may be effected.

A comparison of the cost of the alarm valve equipment with the fire service meters is given in table 1.

Your Committee is of the opinion that no fire service connection should be allowed without the installation of a meter unless the

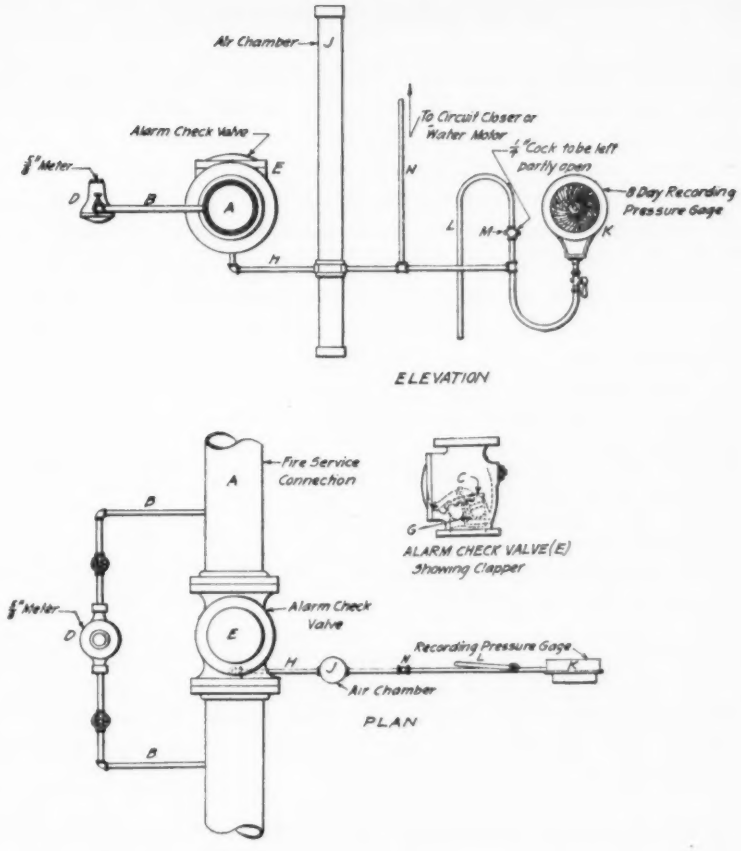


FIG. 3. ALARM VALVE WITH RECORDING GAGE AND SMALL METERED BY-PASS ATTACHED

When the water is drawn through the fire service connection A in small quantities (say less than that required for one sprinkler head) it will go through the metered by-pass B as that path will offer less resistance than the clapper C of the alarm valve E, and its quantity will be recorded on the meter D. When the flow through the system increases, however, the resistance in the by-pass will become so great as to force the water through the alarm valve. In that case, the clapper in the alarm valve is raised, thus opening the port G in the small pipe H. An air chamber J is placed on this pipe to care for water hammer and to serve as a retarding chamber to prevent false alarms. The pipe H then connects to a recording pressure gage K. A vent pipe L with a cock M kept partly closed, relieves the pressure in pipe H when the clapper on the alarm valve returns to its seat. The recording gage thus registers the time the water is flowing through the alarm valve. A small pipe N leads from pipe H, connecting same with a circuit closer or water motor. On water rising in pipe N, the circuit closer or water motor is operated thus sounding the fire alarm.

"bond-alarm-inspection-system" is adopted, and, furthermore, that meters should be placed on all fire service connections where water is drawn therefrom for other than fire uses.

TABLE 1

Comparison of cost of alarm valve equipment with fire service meters

	METER SIZE IN INCHES			
	3	4	6	8
Cost of alarm valve (excluding circuit closer), metered by pass, and pressure recording gauge, all in place in a concrete vault.....	$340	$350	$390	$450
Cost of meter in place in a vault, with an alarm valve (excluding circuit closer) in the building protected...	$400–$460	$500–$600	$700–$900	$950–$1250

(3) HOW SHALL PRIVATE FIRE SERVICE PIPES BE CONTROLLED WHERE THEY ENTER BUILDINGS IN PRIVATE PROPERTY SO THAT IN CASE OF THE BREAKING OF THE INSIDE PIPE, OR OF THE SERVICE PIPE, WATER MAY BE SHUT OFF AND BLEEDING OF THE WATER SYSTEM PREVENTED?

In treating of the question of control of private fire service pipes to prevent bleeding, it must be remembered that sprinklers alone do not always extinguish fires. We submit in table 2 (taken from the "Crosby-Fiske-Forster Hand Book of Fire Protection") a selection of fires in different classes of industry taken from the records of the National Fire Protection Association covering over 20,000 fires in sprinklered plants. Commenting on this table it may be noted that sprinklers extinguish on the average approximately 70 per cent of the fires, so that in 30 per cent of the fires occurring in sprinklered risks other agencies must be called into play in order to extinguish the blaze.

Unsatisfactory fires are those in which the combination of sprinklers and other fire fighting agencies fail to extinguish the blaze. The difference between fires extinguished and unsatisfactory fires represents the fires held in check by the operation of sprinklers until outside assistance arrives.

The record of the 20,000 or more fires in sprinklered plants indicates that about 5 per cent of all the fires reported are failures in that the automatic sprinklers do not hold the fire in check sufficiently to enable the blaze to be extinguished by outside fire fighting agencies. Of this 5 per cent about one-quarter are due to closed gate valves, or, in other words, about 1.25 per cent of all fires reported are not controlled because water is shut off at the time of the fire. In other words, failures due to inefficient operation of the sprinkler system.

TABLE 2

Fires in sprinklered plants of different classes of industries

INDUSTRY	NUMBER OF FIRES	PERCENTAGE OF FIRES EXTINGUISHED BY SPRINKLERS	PERCENTAGE OF UNSATISFACTORY FIRES	PERCENTAGE OF UNSATISFACTORY FIRES DUE TO DEFECTIVE EQUIPMENT	PERCENTAGE OF UNSATISFACTORY FIRES DUE TO HAZARDS AND OBSTRUCTIONS
Boots and shoes	541	74.3	3.9	0.9	0.2
Celluloid	134	69.4	11.9	2.3	8.0
Clothing	582	80.2	1.2	0.2	0.2
Cordage	276	66.3	3.3	1.4	0.7
Cotton mills	5,052	61.7	1.1	0.4	0.04
Furniture	574	64.6	8.4	2.4	2.6
Grain elevators	55	36.4	27.2	12.7	5.5
Knitting mills	615	64.1	3.7	2.4	0.0
Mercantile	680	79.4	2.2	2.9	0.0
Metal workers	751	64.8	4.8	2.0	0.1
Oil cloth and linoleum	79	27.8	20.3	4.0	15.2
Paper	498	51.4	10.0	4.6	0.6
Printing	440	80.0	3.0	1.1	0.0
Saw and planing mills	144	42.4	25.0	8.4	2.1
Woolen mills	1,076	71.2	4.9	2.5	0.01

These data have an important bearing on the question of bleeding a water works system, for if the sprinkler system fails to extinguish the fire and outside agencies have to be called in to extinguish it, as happens in about 30 per cent of the fires in sprinklered risks, bleeding of water mains due to broken fire service connections or broken sprinkler equipment within the buildings may not only react against the sprinklered property but seriously jeopardize all surrounding property.

A study of the history of nearly all conflagrations indicates the enormous loss of water sustained through broken service connec-

tions, not alone fire connections but ordinary service connections, as the result of failing walls or from other causes. (Appendix 2.)

The bleeding of mains due to broken service connections or through the breaking of the sprinkler piping within buildings during times of fire is not alone restricted to conflagrations but happens frequently where an individual building is consumed or badly damaged. Of course, the breakage of any service pipe is a serious matter, but as the size of fire service connections called for is, as a rule, larger than ordinary connections, the hazard from these large connections is by so much the greater. It is a source of wonder, therefore, why the underwriters, in view of their general interest in the conflagration hazard, are willing to jeopardize the locality as a whole in order to go the limit for each individual risk, and why, instead of this policy, they do not insist upon limited-size connections and other precautions necessary to safeguard the situation as a whole.

It has long been the almost universal practice to provide a valve on fire service connections near the main in the street to prevent bleeding of the water system in the event a fire service connection breaks during a fire, as well as to preclude the loss of water through the destruction of a sprinkler piping system. It has also been the universal custom to provide another controlling valve just inside the property line.

The street valve near the main is necessary in order that the water purveyor may have absolute control of all connections from their system. The valve on the private property is necessary to give the owner the means of shutting off water without interfering with the inside water system.

Unfortunately, the proper location of the control valve in the street has not, in many cases, been given the careful consideration which it warrants, with the result that these valves have frequently been covered with debris from falling walls and have, therefore, been rendered inaccessible for the purpose of shutting off broken services or sprinkler piping systems. The custom of using indicator posts on control valves has not always been followed with the result that delays have been encountered in locating the control valves.

It has come to be generally recognized that all private fire service supplies must be so controlled that they cannot endanger the safety of adjoining property by bleeding the water system. In

some cases, it is possible to provide adequate protection against bleeding by installing a valve with indicator post at the building line or curb line. This would be the case where the protected building is located at a sufficient distance from the street to insure access to the valve under all conditions. (See condition 1, figure 4). In other cases, where the building line is close to the curb line, it may be necessary to place the valve across the street from the building and loop the service line to secure proper access in time of fire (see condition 2, figure 4). It should be remembered however, that during a large fire the heat alone will be sufficient to prevent access to the valve unless the space between the burning building and the valve is appreciable. It is always advisable as an additional precaution, where streets are narrow, to gate the street mains (see conditions 3 and 4, figure 4), so that in case of necessity not more than a block length, or a maximum of 500 feet of main, will be shut off in the event of the control valve becoming inaccessible for any reason.

Some type of valve which will close automatically if the flow through a fire service connection exceeds a given amount may be devised, or some method of remote control of the shutoff valve may be possible. So far as your Committee has been able to determine, nothing of this type has been developed to date, but there are no insurmountable difficulties in the way of securing either an automatic valve or a valve which may be remotely controlled. Designs for a valve of this type by the Larner-Johnson Valve & Engineering Company of Philadelphia are well under way. The use of this valve in fire service lines has not been approved by the National Board of Fire Underwriters, but it is the understanding of your Committee that the valve is being investigated by this Board and the outlook for its application to this type of service is promising. This valve may be adapted not alone to automatic control, but to distant, electric or hydraulic control, and if the details can be worked out successfully, and at this time it appears that they can, this valve may solve the problem of absolute shutoff of broken service connections in time of fire. If automatic or distant control can be satisfactorily worked out, one of the greatest elements of danger to surrounding property resulting from the installation of private fire service lines will be removed, and the responsibility of the water purveyor in this connection will be materially lessened.

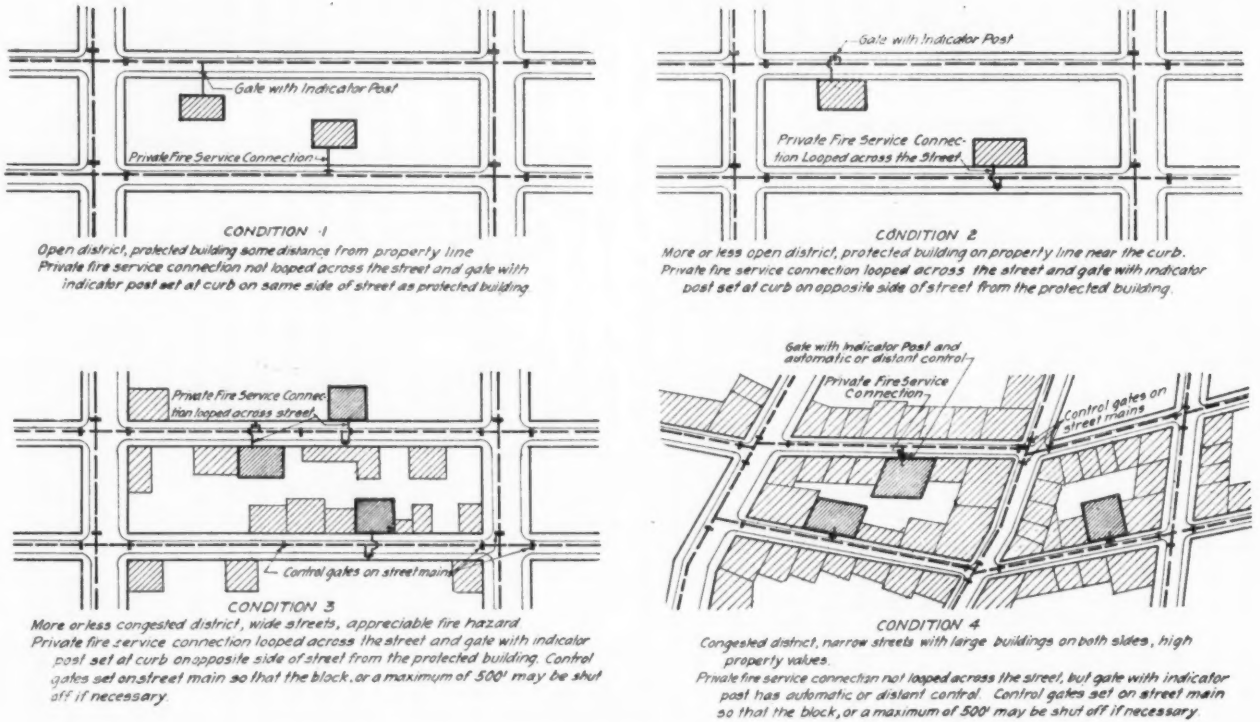

Gate with Indicator Post
Private Fire Service Connection
CONDITION 1
Open district, protected building same distance from property line
Private fire service connection not looped across the street and gate with indicator post set at curb on same side of street as protected building
Gate with Indicator Post
Private Fire Service Connection Looped across the Street
CONDITION 2
More or less open district, protected building on property line near the curb.
Private fire service connection looped across the street and gate with indicator post set at curb on opposite side of street from the protected building.
Private Fire Service Connection looped across street
Control gates on street mains
CONDITION 3
More or less congested district, wide streets, appreciable fire hazard
Private fire service connection looped across the street and gate with indicator post set at curb on opposite side of street from the protected building. Control gates set on street main so that the block, or a maximum of 500' may be shut off if necessary.
Gate with Indicator Post and automatic or distant control
Private Fire Service Connection
Control gates on street mains
CONDITION 4
Congested district, narrow streets with large buildings on both sides, high property values.
Private fire service connection not looped across the street, but gate with indicator post has automatic or distant control. Control gates set on street main so that the block, or a maximum of 500' may be shut off if necessary.

FIG. 4. LOCATION OF GATES FOR PROPER CONTROL OF CONNECTIONS

Figure 5 is an outline drawing of the Johnson hydraulic valve with a brief description of its method of operation. This drawing and outline are submitted with the hope that they may stimulate interest in the development of a workable device of this type.

In conclusion, your Committee recommends that in open areas where the protected buildings are some distance from the property line, proper control may be secured through the installation of a gate valve with indicator post at the curb line where the fire service connection enters the property (see condition 1, figure 4).

In more or less open areas, where the building to be protected is on the property line close to the curb, the service connection should be looped across the street and the gate valve with indicator post set on the opposite curb (see condition 2, figure 4).

In more or less congested districts, where the fire hazard is appreciable, but where streets are wide, the least that can be done is to secure the best location possible for the gate control and indicator post and, in addition, to gate the mains adjacent to the protected property so that, in the event the control gate is rendered inaccessible, other valves may be manipulated by means of which the fire service supply of the protected property may be shut off (see condition 3, figure 4).

In congested districts, with narrow streets and with large buildings on both sides of the street, where property values are high and large service connections are required for heavily sprinklered risks, the installation of automatic or distant control is recommended as soon as a suitable device for this purpose is developed (see condition 4, figure 4).

Figure 4 gives a suggestion of the method of gating the mains and installing the gate controls and indicators on fire service connections so as to secure reasonably adequate protection.

(4) WHAT LIMIT SHOULD BE PLACED UPON THE SIZE OF THE PRIVATE FIRE SERVICE CONNECTION?

The size of private fire service connections which should be permitted depends not alone upon the adequacy of the means provided for controlling them to prevent bleeding of the water system, but also upon the design and capacity of the water distribution system in the vicinity of the risk. It is difficult, therefore, to lay down a hard and fast rule.

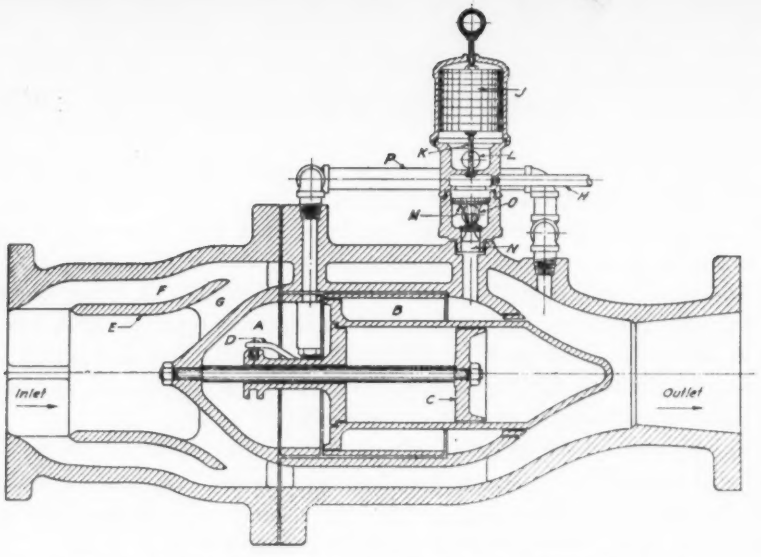


FIG. 5. SELF-CLOSING VALVE FOR FIRE PROTECTION SERVICE

The valve consists essentially of a circular body containing an internal concentric cylinder supported by ribs and closed at one end, in which there is a differential plunger with a conical nose which seats inside the neck of the valve body. The differential plunger divides the internal cylinder into two operating chambers: a central or "closing chamber," *A*, and an annular or "opening chamber," *B*. The plunger is opened by exhausting chamber *A* and applying pressure to chamber *B*, and is closed by exhausting chamber *B*, and applying pressure to chamber *A*. The dashpot *C* is used merely to control the rate of closing of the plunger. The piston is stationary being tied rigidly to the back end of the internal cylinder and the plunger moves relative to the piston; *D* is an indicator mechanism to show on the outside of the valve the position of the plunger.

The inlet end of the valve has two water passages, *F* and *G*, separated by a cylindrical wall, *E*. Ordinarily the water flows through *G* but in case any considerable obstruction comes in through the pipe line, this obstruction will be caught in the space inside of *E* plugging up passage *G* and the water will then flow through *F*.

The automatic closing feature is accomplished by the weighted valve *K* on top of the body. This valve is connected by a pipe, *H*, to the main supply line at the lowest sprinkler level and the weights *J* on valve *K* are adjusted so that valve *K* will drop when the pressure under it falls below the minimum useful pressure at the sprinkler level plus the static elevation of this point above valve *K*. For example, if 15 lbs. pressure is the lowest pressure which is of any use on the sprinklers and the lowest sprinkler level is 20′ above valve *K*, then the latter would be weighted to drop as soon as the pressure under it falls below 15 lbs. plus 20 ft. The pipe *H* is run either inside or outside of the supply line to the sprinklers.

As soon as valve *K* drops, the pressure in the chamber below it exhausts to the atmosphere through pipe connection *L* whereupon the double seated valve *M*, which is held closed by the pressure on top of it, opens due to the pressure coming up under it through passage *N* which latter pressure is thus exhausted to the atmosphere through pipe connection *O*. This results in the pressure being exhausted from chamber *B* and the plunger immediately starts to close, water being supplied to chamber *A* from the body of the valve through pipe connection *P*.

With respect to the amount of water which is required for private fire protection, Table 3 gives the discharge per sprinkler head at varying pressures.

While it is true that the great majority of fires are controlled by the opening of not to exceed ten sprinkler heads, there are many cases recorded where fifty sprinklers have opened for a quick fire. In some cases the number of sprinklers which have opened is appreciably in excess of this. It is a principle of automatic sprinkler protection that if fires occur in a sheltered position so that water from sprinklers cannot reach them, the heat produced, flowing through the room, may open many sprinklers before the water discharged is able to cool down the heat as fast as it is produced. Table 4 gives a list of fires reported where 25 or more sprinkler heads have opened.

TABLE 3

Discharge per sprinkler head at varying pressures

PRESSURE ON SPRINKLER HEAD WITH WATER FLOWING	DISCHARGE PER HEAD PER MINUTE	PRESSURE ON SPRINKLER HEAD WITH WATER FLOWING	DISCHARGE PER HEAD PER MINUTE
pounds	*gallons*	*pounds*	*gallons*
5	12	30	31
10	17	50	40
15	21	75	50
20	25	100	58

The amount of water necessary for a good sprinkler supply is not closely connected with the number of sprinkler heads, and the water supply needed cannot be measured definitely by the number of sprinklers to be supplied. A 50 x 100-foot room will ordinarily have more than 50 sprinklers, and this is a small room for a manufacturing plant. More water will be needed in a plant having large undivided areas than in one which is more closely subdivided, as the chief reliance for safety in large undivided areas is sprinklers, and it may be necessary to have water enough to supply 100 or more sprinklers if such a building is to be reasonably protected. Consideration must be given to the size of single buildings and the character of the occupancy. It is, therefore, difficult to compress private fire service requirements into rules.

The requirements may be stated in a general way as follows: Fair average pressure on the sprinkler heads may be taken as about 20 pounds. From Table 3 it will be seen that the discharge

TABLE 4

List of 30 cases where 25 or more sprinklers opened out of 786 fires reported between January 10, 1907, and June 12, 1908

KIND OF FACTORY	NUMBER OF SPRINKLERS WHICH OPENED	CAUSE OF OPENING OF SO MANY SPRINKLERS
Cotton mill.....	All sprinklers on upper floors. Several hundred	Water shut off for repairs when fire started; turned on in ten minutes, but fire spread in the meantime, opening many heads.
Cotton mill.....	25	Fire started in blower handling cotton and was first seen dropping from the condenser.
Cotton mill.....	All sprinklers	Storehouse fire, and unprotected openings between floors allowed fire to reach upper stories.
Machine shops....	All sprinklers on third and fourth and few on second floors	Tank water was shut off from all sprinklers in building so no supply available until pump started and another shut valve kept pump water from one section.
Cotton mill.....	60	Fire started in opener room, dropped on floors and spread over cotton.
Paper mill.....	All in sulphite digester and dynamo rooms	Public water which was primary supply to sprinklers probably shut off when fire started.
Carpet factory....	33	Fire ran over card and in lint on ceiling and floor.
Cotton mill.....	27	Dust room fire.
Cotton mill.....	35	Storehouse fire—small stones obstructed one section of pipe.
Cotton mill.....	33	Fire ran over tops of dryers.
Cotton mill.....	27	Fire started in cotton in picker. Two Greeks ran away instead of using hose.
Silk mill.....	48	Fire started over boiler room and water was shut off sprinklers at the time.
Machine shop.....	27	Burning lacquer floated over floor.
Cotton mill.....	75	Storehouse fire.
Cotton mill.....	47	Cotton storehouse.
Cotton mill.....	32	Cotton storehouse.
Paper mill.....	50	Fire burned over dryers and hood.
Paper mill.....	101	Fire started in pit under machine and spread to hood. No sprinklers under hood so roof sprinklers finally controlled fire.

TABLE 4—*Continued*

KIND OF FACTORY	NUMBER OF SPRINKLERS WHICH OPENED	CAUSE OF OPENING OF SO MANY SPRINKLERS
Carpet factory....	257	Fire started in mule where water could not reach until fire burned through.
Cotton mill.....	90	Fire started in old attic and spread in hollow space so first sprinklers could not work effectively.
Cotton mill.....	67	Fire in blow bin. The blast of hot air from blow pipe opened all sprinklers in room.
Cotton mill.....	38	Dust room fire.
Cotton mill.....	46	Storehouse fire.
Cotton mill.....	650	Fire travelled through belt boxes to several stories.
Paper mill.....	60	Sprinklers were missing about bins, due to recent rebuilding at time of fire.
Cotton mill.....	54	Storehouse fire.
Cotton mill.....	156	Dye house fire. Hose streams drew pressure away from sprinklers and no water was pumped into sprinkler system.
Jute goods mill...	25	Storehouse fire.
Paper mill.....	56	Heat passed through conveyor.
Cotton mill.....	26	Storehouse—deep piles.

at this pressure is 25 gallons per minute per sprinkler. For small plants, 500 to 750 gallons per minute will be satisfactory. For average sized manufacturing properties, 750 to 1,000 gallons per minute is as small a supply as will give good protection. For large plants, 1,000 to 1,500 gallons per minute is desirable, and for very large plants 2,000 gallons per minute or more are needed. A supply figured on this basis would in most cases be adequate for hydrants and standpipes on the property as well as for the sprinkler heads.

The insurance people suggest that 4-inch connections be used for small equipments, and that 6-inch connections be permitted where the size of the risk requires more water than a 4-inch pipe can deliver. In special cases for large risks, it is common to install 8-inch and 10-inch fire service connections. Where the arrangement of buildings permits, additional capacity may be secured, without materially increasing the hazard from bleeding, by dividing the private fire equipment into two or more sections and taking connec-

tions from different street mains, or from well separated points on the same main. By so doing, if one service connection is rendered inaccessible and cannot be shut off, the other service connection may be controlled and in this way less water will be wasted than if the entire supply were taken through a single service connection.

Great care should be exercised, however, in the granting of multiple connections, as the more connections allowed the larger the number of valves and other devices to be cared for and inspected. In granting multiple connections, particular care should be given to the piping layout inside the building. If such connections are brought inside the building to a common pipe or header, and if this header should be wrecked, as much water will be wasted through several small connections as through one large one. Multiple connections should only be granted on subdivided inside equipment.

It is obvious from the preceding figures that even the smallest sprinkler system requires an amount of water which is equivalent at ordinary pressures to two or three fire streams through $1\frac{1}{8}$-inch hose nozzles. The larger risks require the equivalent of four to eight fire streams of a similar size. There are few places which have reserve fire fighting capacity sufficient to lose three to eight fire streams and at the same time provide a sufficient number of streams for the proper protection of property. The worst feature of a sprinklered risk is that when public fire protection is most needed, the conditions in the sprinklered property are such that a large number of sprinkler heads may open and the liability to breakage of the sprinkler pipes, or even of the service connection, is most serious. It should be recalled in this connection (see Table 2) that the fire department has to be called into play in about 30 per cent of the sprinklered fires. The loss of from three to eight streams under these circumstances places a serious handicap on the ability of the fire fighting apparatus to protect not only surrounding property but the sprinklered risks as well.

A supplemental supply stored in elevated tanks should be prescribed wherever possible for private fire service protection in order to reduce the size of connections and thereby maintain the integrity of the public fire protection. If a supplemental supply is provided and control valves are properly placed at the entrance of the property, so that when the sprinklered risk gets beyond control and surrounding property si seriously endangered, the fire service connection may be promptly shut off, the danger from these connections will be largely removed.

TABLE 5

Relative flow capacity of pipe. Based on assumption that relative deliveries at same loss of head are to each other as 5/2 power of the respective diameters

DIAMETER IN INCHES	DIAMETER IN INCHES																	
	4	6	8	10	12	14	16	18	20	24	30	36	42	48	54	60	72	84
	Relative flow capacity																	
84	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.0	13.1	8.3	5.65	4.05	3.0	2.3	1.47	1.0
72	.....	.....	.....	.....	.....	.....	.....	.....	24.5	15.6	8.9	5.67	3.83	2.75	2.05	1.6	1.0	.....
60	.....	.....	.....	.....	.....	.....	.....	20.3	15.6	9.9	5.7	3.6	2.43	1.75	1.3	1.0	.....	.....
54	.....	.....	.....	.....	.....	.....	20.7	15.6	12.0	7.6	4.85	2.76	1.87	1.44	1.0	.....	.....	.....
48	.....	.....	.....	.....	.....	21.7	15.6	11.6	8 92	5.66	3.24	2.05	1.39	1.0	.....	.....	.....	.....
42	.....	.....	.....	.....	23.0	15.6	11.05	8.33	6.4	4.05	2.32	1.47	1.0	.....	.....	.....	.....	.....
36	.....	....	.....	24.6	15.6	10.6	7.6	5.66	4.35	2.76	1.58	1.0	.....	.....	.....	.....	.....	.....
30	.....	.....	27.2	15.6	10.0	6.7	4.8	3.6	2.76	1.75	1.0	.....	.....	.....	.....	.....	.....	.....
24	.....	32.0	15.6	8.9	5.66	3.85	2.76	2.05	1.58	1.0	.....	.....	.....	.....	.....	.....	.....	.....
20	56.0	20.28	9.9	5.66	3.6	2.44	1.75	1.3	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	43.0	15.6	7.6	4.35	2.76	1.87	1.34	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	32.0	11.6	5.7	3.24	2.05	1.40	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	23.0	8.3	4.05	2.32	1.47	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	15.6	5.66	2.76	1.58	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	9.9	3.6	1.75	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	5.66	2.05	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	2.76	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

The tanks required for supplemental supplies are not large. The National Board of Fire Underwriters requires tankage of a capacity to supply from 25 to 150 sprinkler heads for 20 minutes at the rate of 25 gallons per minute. In other words, they consider tanks of from 12,500 to 75,000 gallons sufficient for the suppression of incipient fires, for which purpose the sprinkler system is most useful. Elevated tanks of 12,500 gallons capacity cost approximately $5,000, and an ordinary elevated tank of 75,000 gallons capacity approximately $10,000.

It may be desirable to have tanks of slightly larger size than prescribed by the National Board of Fire Underwriters, and the curves on figure 6 give the capacity of tanks required to provide one hour's supply for varying numbers of sprinkler heads at varying quantities of flow per sprinkler head. This diagram also shows how large the service pipe should be to supply a given number of sprinkler heads with a given storage capacity, assuming a velocity of 5 feet per second in the service pipe. Any combination of size of tank and size of service, which may be equitable and suitable to particular conditions, may be ascertained from the diagram.

Assume, for example, that the water purveyor has an 8-inch main in the street and that the fire service connection, properly guarded by control valves to prevent bleeding, is permitted to have a capacity equal to 50 per cent of that of the main. By looking at Table 5, which gives the equivalent sizes of pipes, one will find that an 8-inch pipe is about equal to two 6-inch pipes. Hence the fire service connection may be a 6-inch pipe. Assume further that the insurance people figure the risk should have a supply of 2,000 gallons per minute. This is equivalent to the simultaneous discharge of 80 sprinkler heads at the rate of 25 gallons per minute each at 20 pounds pressure. To determine the capacity of the tank necessary to meet this requirement, start from point (*a*) on the scale (*A*) at the bottom of the diagram, representing a discharge of 25 gallons per minute per sprinkler head, and follow the vertical dotted line (*a*)–(*b*) to (*b*), its intersection with the oblique line marked 80, representing the number of sprinkler heads; thence follow the horizontal dotted line (*b*)–(*c*) to (*c*), its intersection with scale (*B*) at the left of the diagram, which shows that the total amount of water required is 120,000 gallons; then as the tank supply is supplementary to the discharge of a 6-inch service connection, follow the horizontal dotted line (*c*)–(*d*) to (*d*), its intersection with

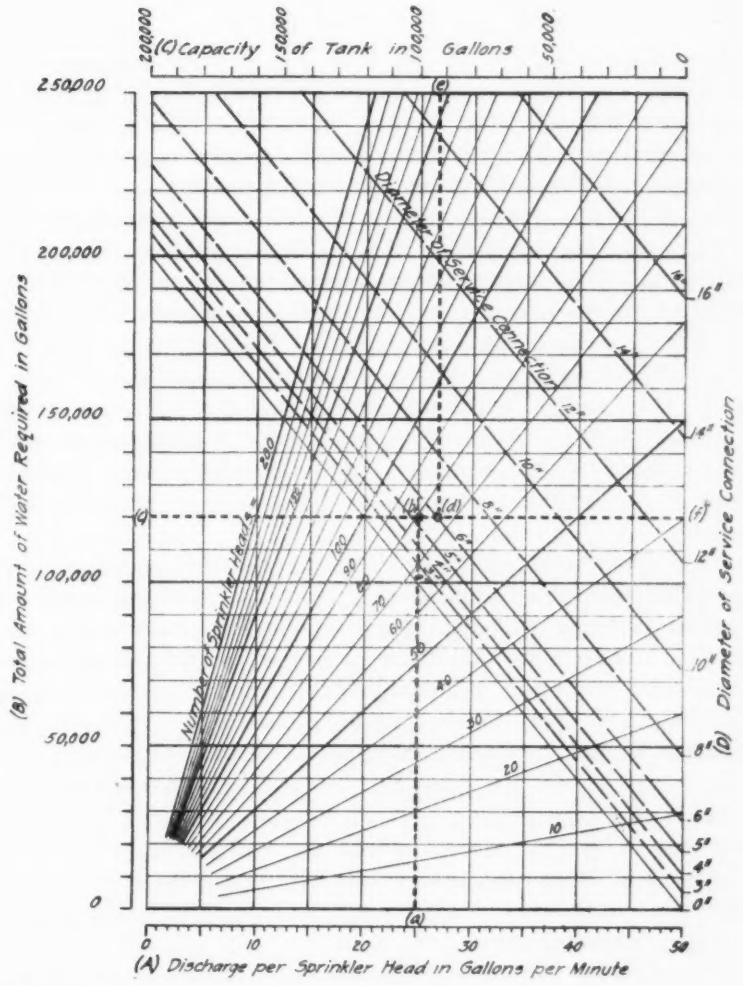


FIG. 6. RELATION BETWEEN WATER SUPPLY REQUIRED FOR AUTOMATIC FIRE SPRINKLERS IN BUILDINGS, TANK CAPACITY AND SIZE OF SERVICE CONNECTION.

Based on one hour's supply and a velocity of 5 feet per second in the service pipe.

the oblique line marked 6 inches and representing a 6-inch service connection; thence follow the vertical dotted line (*d*)–(*e*) to (*e*), its intersection with scale (*C*) at the top of the diagram, which shows that the capacity of the tank necessary to supplement the discharge of a 6-inch service connection is 92,000 gallons. For the conditions assumed, then, a tank of 92,000 gallons capacity will be required as a supplementary supply in order to satisfy the requirement of 2000 gallons per minute for one hour, or, if twenty minutes' supply is satisfactory to the insurance interests, the size of tank may be one-third of this, or 31,000 gallons. If no tank were installed the diameter of the service connection required would be 12 inches, as is seen from the diagram as follows: 2000 gallons per minute = 120,000 gallons per hour. Start at point (*c*) on scale (*B*), (120,000 gallons). Follow horizontal dotted line (*c*)–(*f*) to point (*f*) on scale (*D*). It will be seen that this point lies between a 12-inch and 14-inch service connection. A 12-inch connection would, therefore, be necessary to give the same protection without tankage as the 6-inch connection gives with tankage of 92,000 gallons.

Your Committee wishes to stress the value of encouraging the use of supplemental supplies for private fire service protection to prevent bleeding at times when outside fire protection is most needed. There is no doubt that a proper solution of the private fire service connection problem demands that a reasonable limitation be placed upon the size of such connections. The late Albert Blauvelt, one of the leading insurance experts of the country in his day, stated before the American Water Works Association (*Proceedings*, 1913, page 178): "It is a question whether the present tendency to large fire service connections will not lead to a state of affairs where large connections will be so numerous as to convince everyone that the general water supply will be completely jeopardized in times of conflagration."

The necessity for large private fire service connections may be obviated by the judicious use of elevated tanks to provide a supplemental supply to be drawn upon in the event of fire. In view of the enormous saving in insurance, as well as in the losses due to the interruption of business which private fire protection secures, it does not appear that a hardship will be imposed by requiring that a supplemental supply be provided. In so doing the heavy draft on the distribution system in times of fire is reduced and the conflagration hazard to nearby property is minimized.

The danger of a wide spreading fire, commonly termed a conflagration, exists in every city and town in the United States and Canada. The conditions which made possible conflagrations such as those in Atlanta, Augusta, Baltimore, Bangor, Boston, Chicago, Nashville, New Orleans, Salem, San Francisco and Toronto, and many lesser ones exist today to a large extent in all our built-up sections.

It is pertinent at this point to bring up the question of the liability of the water utility for loss from fire due to its failure to provide an adequate supply, for while in the majority of cases the weight of authority denies any liability for such damage on the part of the utility, in three states a contrary rule has been announced and adhered to. If the principle of liability of the water utility for damage to individual property for loss from fire is extended for any reason, the importance of restricting the size of private fire service connections will be greatly emphasized. (Appendix 3.)

Your Committee is of the opinion that while the water purveyor should be as reasonable as possible in his attitude towards the insurance people, the capacity of a private fire service connection should in no case exceed 50 per cent of the capacity of the main supplying it, and in the event such a limitation will not satisfy the water requirements of the risk to be protected, then that elevated tanks be required to supplement the direct demand on the distribution system.

(5) WHAT MEANS SHALL BE ADOPTED TO PREVENT THE POLLUTION OF A PUBLIC WATER SUPPLY THROUGH A PRIVATE FIRE PROTECTION SERVICE WHEN AN INDEPENDENT WATER SYSTEM IS ALSO CONNECTED WITH THE FIRE PROTECTION SYSTEM?

It has become the common practice of underwriters to require an independent water supply, either furnished direct through fire pumps, or through fire pumps to elevated tanks, in the case of large and valuable properties having private fire protection. The purpose of the independent supply is to duplicate the service, or supplement the capacity of the public water supply. In some cases, the pressure on the public mains is not sufficient to deliver water to the highest sprinkler head. In such cases, the pressures on the independent supply are greater than on the public supply. Under these conditions, it is necessary to install check valves in the private fire service connection with the public mains in order to

prevent the water in the private fire protection system from discharging into the public mains.

The independent fire protection supplies are generally secured from the nearest stream, river, or pond, the water of which is not infrequently polluted. Typhoid fever epidemics in a number of places have been positively traced to the pollution of water in public mains through improperly protected connections with private fire systems upon which greater pressures were maintained than upon the public mains. (Appendix 4.)

The danger attending the existence of such connections is obvious, unless a positive and reliable means is provided for preventing flow reversal therein.

There are two general courses between which to choose to safeguard a public water supply from this danger. One is to prohibit the connection of private fire protection service lines with the public system unless such private fire protection system derives its water wholly from the public supply or partially from other sources which are equally as pure. The other course is to require a reliable means of positively preventing a reversal of flow through the private fire service connection.

The first course will secure absolute immunity from the danger referred to, and has been claimed by some to be the only one which is to be relied upon. Letters of inquiry directed to the State Boards of Health of a number of states, however, develop the fact that there is no uniformity of practice in this matter.

The Minnesota State Board of Health passed a resolution on October 8, 1918, requiring that there should be no physical connection between water supply systems that are safe for domestic use and those that are unsafe for domestic use.

The practice in Pennsylvania in cases where the independent supply is not suitable for domestic purposes and where the use of such a supply endangers the public supply, is absolutely to forbid any connection between the two systems without a special permit. Such permits are granted only when the conditions appear to be such as to demand a cross connection. A few permits for a system of double check valves with test gauges and drain connections, similar to that shown on figure 7, have been issued with the understanding that a joint test of the water-tightness of the check valve be made each month by a representative of the protected property and of the water company, and a written report of the conditions so found made

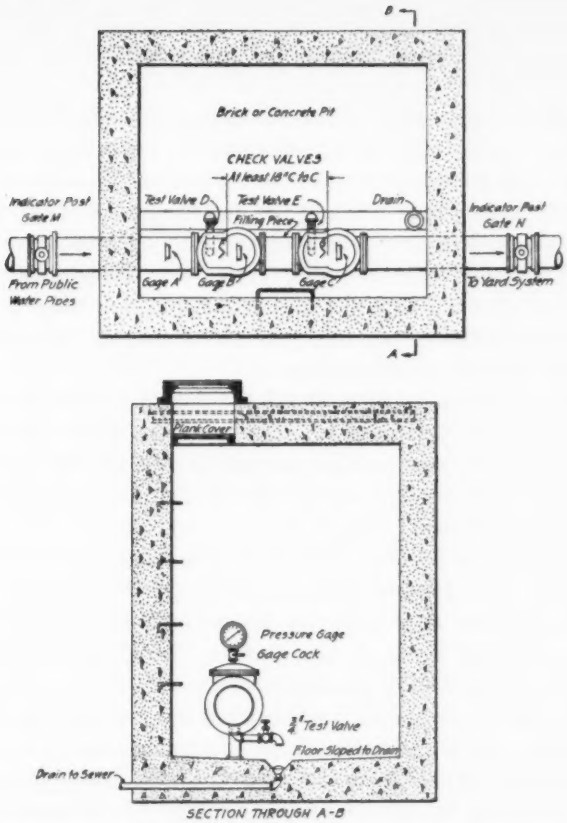


FIG. 7. FIRE SERVICE CONNECTION USING TWO "TYPE F. M." CHECK VALVES

Method of testing. Open test valve *D* to blow out any sediment that may have accumulated in test valve or connecting pipe and then close. Close gate *M* and open test valve *D*. If pressure falls at gage *A* and pressure at gage *B* holds after decreasing slightly, check *F* is tight. While test valve *D* remains open and pressure at gage *A* stands at zero, open test valve *E*. If pressure at gage *B* falls to zero and flow from test valve *E* ceases, check *G* is tight.

Normal conditions of valves. Open; Indicator Post Gates *M-N*. Shut, test valves *D-E*.

Notes. The specifications under which these special check valves are made require the seat ring, disc, holding ring and screws, disc stud, arm, hinge pin and bushings to be of bronze; disc to be faced with medium hard rubber and liberal clearances left around clapper and arm in all positions. For approved makes of these valves see latest edition of "Approved Fire Protection Appliances."

About once a year inspect check valves and thoroughly clean whole interior.

To facilitate removing check valve bonnets, pack with manila paper and machine oil and grease bolts with heavy oil and graphite.

The pit should be not smaller than about 4 x 5 x 6 feet deep.

Caution. Immediately at close of test, see that gates *M* and *N* are open. It is important that the protection be promptly restored.

to the Health Department. The Pennsylvania State Department of Health also requires that the check valves be opened and thoroughly inspected once every three months. Further, in cases where the independent supply is in ordinary use and the public supply is needed only as an auxiliary and where there is an elevated tank, the requirement is made that the mains from the public system be led over the top of the elevated tank and discharge above the surface so that there will be no possibility of backflow from the independent fire system into the public supply.

In response to an inquiry, the State Board of Health of Michigan stated that it preferred to have no direct physical connection between the public and private service, but where this is not practicable it has advised the installation of double check valves, substantially as indicated on figure 7.

The Massachusetts Department of Health thinks it doubtful if it will make any general ruling relating to this matter, as there are so many questions involved in determining what is best to do in each case, and the circumstances vary so greatly in different cases, no one rule is considered practical.

The Ohio State Board of Health takes the attitude that any connection from the distribution pipes of a public water supply to a private piping system which carries polluted water is potentially dangerous, and in its opinion absolute safety can be secured and the public water supply made available for fire protection only by the following methods:

> First Construction of a pump well or reservoir to which the city mains are connected, pumps taking suction from well or reservoir and pumping to an elevated tank for storage and pressure.
>
> Second An elevated tank or standpipe supplied at the top and above the overflow by a connection from the city main. Such tank or standpipe may then be connected to the fire protection system.
>
> Third Two independent systems of piping without any connection whatsoever, one being supplied from the city mains and the other from the independent water supply.

The Ohio State Board of Health has permitted cross connections between public and private water supplies with the use of double check valves, but has withheld approval of this method of procedure.

The State Department of Health of New York feels that it would be making a sufficient step in advance if the double check valve, properly installed and supervised, were adopted, as this is so great an improvement over the past "hit or miss" condition of installation in many, if not most, of the factories having a dual supply.

The use of a single check valve of poor construction in a cross connection between the public mains and a polluted private supply is obviously out of the question. The Massachusetts State Board of Health reports that recently a city engineer, on taking out three check valves connected with a river supply, found one of them in fair condition and probably operating satisfactorily, the second in very bad condition and evidently did not close tight, while the third had become fixed at an angle of 45 degrees and evidently had not moved for several years at least. It is possible that similar inspections in other places would disclose the same conditions.

Water works managers generally have not adopted the course of prohibiting cross connections or of requiring the installation of double check valves. Greater safety is unquestionably attained by providing two well-constructed check valves where dependence was formerly placed upon a single valve of but ordinary construction. Let it be said here that too much emphasis cannot be laid on the construction of these valves. Figure 9 illustrates a good type of fire service check valve, designed by the Associated Factory Mutual Fire Insurance Companies and approved by them. It is impossible to state how much more security two high class check valves afford than is afforded by a single one of good or poor construction. So long as it is possible for a single check valve to leak, it is possible for two in series to leak at the same time, and the danger of pollution of the public supply in that way is only reduced, not eliminated, by two check valves, unless there is a regular and constant inspection of those check valves, as called for by the Pennsylvania State Board of Health, and unless ready means are provided for proper tests of the tightness of the check valves by some arrangement similar to that shown on figure 8. It may be that the possibility of leakage through two well constructed check valves, regularly inspected, is so small that official approval of the state boards of health, or other authorities, would be warranted for this method of protecting public water supplies from the danger of pollution from cross connections. It is fair to state that a number of double check valve installations are in service, and so far as

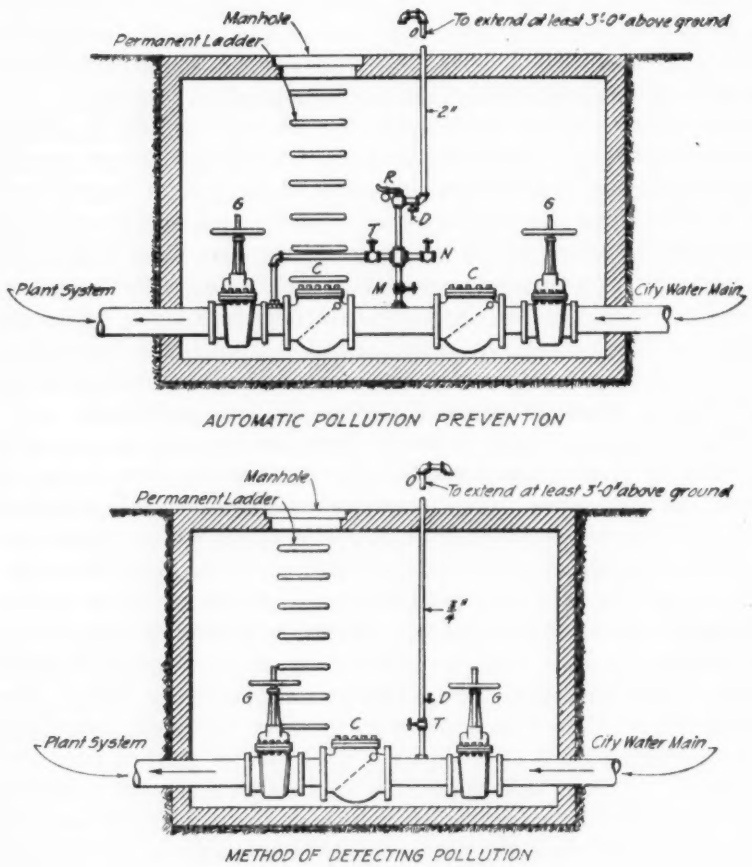
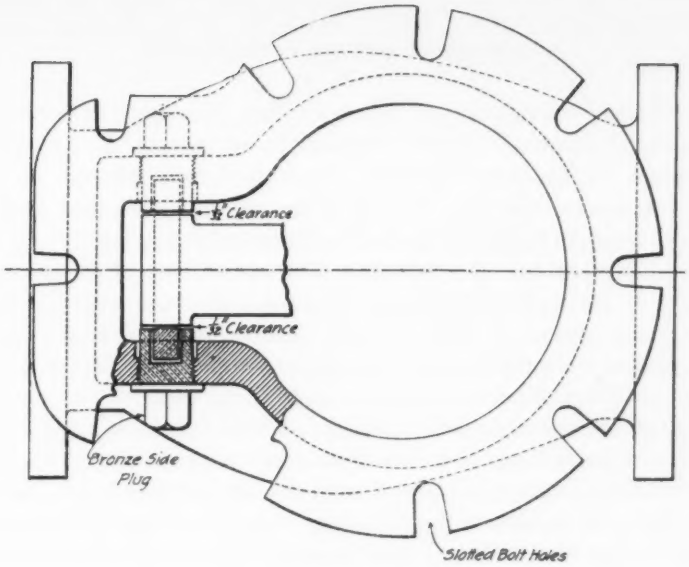
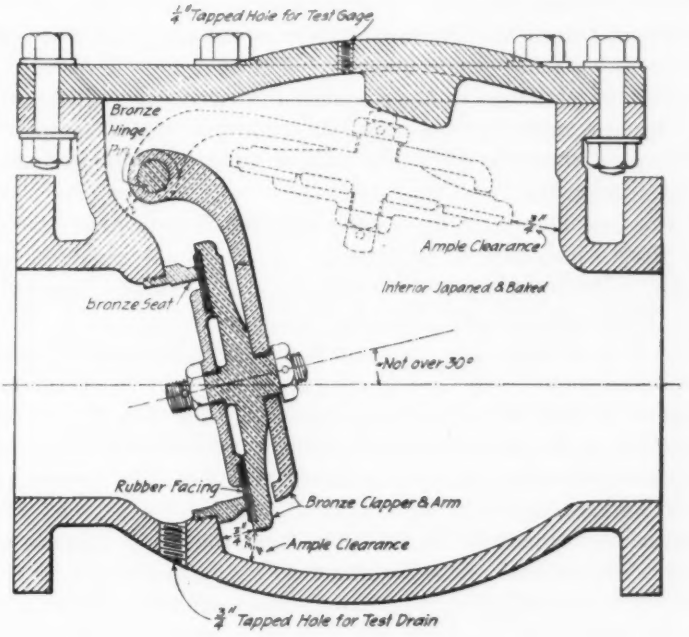


FIG. 8. POLLUTION PREVENTION

G and *G* = Valves controlling the two water supplies, one pure and one polluted or likely to be.
C and *C* = Swing check valves.
R = Relief valve (weighted type preferably).
T = ¾ inch Test valve.
N = Valved connection for pressure gage.
D = Drain valve.
O = Riser.



PLAN



SECTIONAL ELEVATION

FIG. 9. TYPICAL GENERAL DESIGN OF SPECIAL TYPE F. M. FIRE SERVICE CHECK VALVE

NOTE: For specifications see figure 7, page 709.

your Committee has been able to ascertain, they have thus far been considered reliable. They are probably entitled to be regarded as the most reliable form of protection yet tried out. There is no positive assurance, however, that their failure will not occur at some future time unless regularly and systematically inspected.

A refinement has been added to the installation of double check valves in the nature of an electric alarm connected with the check valves, by means of which a bell is rung whenever water from the independent supply enters between the checks. (*Journal New England Water Works Association*, 1916, page 240.)

An additional means of protection which has been tried out on dual systems where the public supply is the primary and the independent source of supply the secondary dependence, is to close and seal the gate valves on the discharge lines of the fire pumps which draw water from the polluted independent source. This method was adopted by the Milwaukee Water Department as stated in its annual report for 1912. Under these conditions, the seals must be broken before the discharge valves at the pump may be opened and the private fire pumps started. While the fire pumps are operating the check valves in the connection between the public and private systems must be relied upon to protect the public supply from pollution, if the pressure in the private fire system be greater than in the city mains.

While not known to have been adopted in any case, there are two plans which present practically perfect, if not absolute, safety against pollution of a public water supply by back flow from private fire systems supplied with polluted water.

The first of these may be termed a "normally closed, manually operated system." With this system a gate and check valve are installed in the private fire service connection, the former in the rear of the latter and a few inches apart, with an open vent in the section between for bleeding or drainage. The gate valve is kept closed and sealed except when open for actual fire service. There are excellent objections to this plan from the fire protection viewpoint. The possible delay incident to the manual operation of a gate valve at a critical time greatly lessens the value of the connection as compared to a gate valve which is normally open or automatically opens.

The second is quite similar to the first, but is more expensive to install. Provision is made for automatic operation by using a

hydraulically operated control gate. The difference between the pressure in the public mains and that of the private fire system is used to operate the control gate and thus automatically opens or closes it, depending upon whether the pressure in the city mains or private fire lines is the greater. The arrangement of this valve is shown in figure 10. So far as is known, it has not been adopted or installed on any private fire service connection.

The objections to cross connections between a pure and a polluted supply are obvious and the attitude which the public takes towards them is such that they should be avoided as far as possible. The probability is that they will be wholly prohibited in many cities on account of public sentiment. On the other hand, it is claimed that the protection of life through adequate sprinkler protection is as important as the protection of health, and if dual connections are not allowed, mill operatives may be burned to death in consequence. The balance up to the present time is on the side of preventing pollution, for undoubtedly many people have been killed or incapacitated by the entrance of polluted water into public mains through fire connections.

The object of all concerned should be to equip all private fire service connections so as to secure absolute safety against pollution of public supplies by back flow. A single rule only is suggested to govern the installation of connections between public water mains and private fire service systems:

> No fire protection system, having an independent water supply which is unsafe for drinking, shall be connected with the public supply mains unless such connection is so equipped as to positively prevent the flow of water from the piping to the public system.

It is the opinion of your Committee that the installation of double check valves may be made efficient in preventing pollution from independent fire supplies if regularly and systematically inspected, but only if such regular and systematic inspection is maintained. The difficulty of securing such regular and thorough inspection in all cases is realized. A suggested arrangement of the double check valves on a private fire protection service to a property having an independent fire supply is given in figure 11.

Your Committee also wishes to call attention to the value of requiring that private fire service connections discharge either into cisterns or elevated tanks where independent water supplies of doubt-

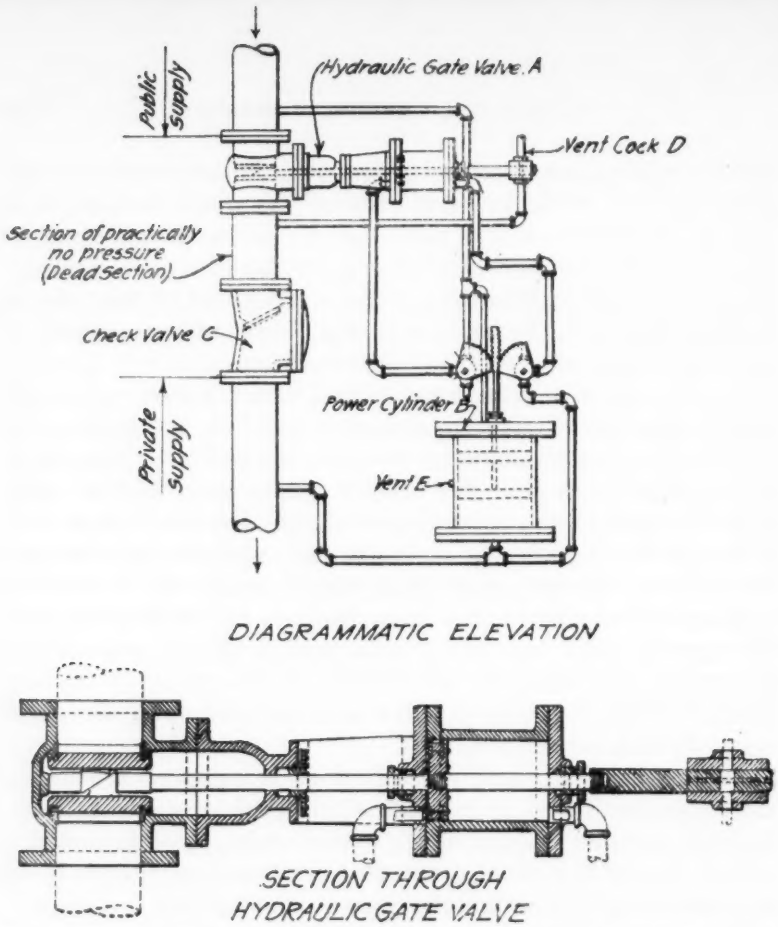


FIG. 10. MILLER DEVICE FOR THE PROTECTION OF PUBLIC WATER SUPPLIES AGAINST POLLUTION THROUGH CONNECTION WITH INDUSTRIAL SUPPLIES

The gate valve *A* is automatically opened and closed by the difference between the pressures in the two systems acting through a separate power cylinder *B* whose piston operates the cock or cocks controlling the hydraulic cylinder gate valve. Another cock is provided which opens with the closing, and closes with the opening, of the gate valve. With the gate valve closed as it will be, automatically, when the pressure in the private system is the greater, this additional cock, then open, provides an outlet for any water leaking past the check *C*. In this way the tightness of the gate and check valves can at any time be readily determined by external inspection by simply noting the rate at which water is escaping through the open vent cock *D*.

Provision is also made in the design for preventing any by-passing of polluted water by leakage through the separate power cylinder and into the city mains by using two pistons in it on the same piston rod, and a vent *E* at the middle of the length of the cylinder which is always open. Neither piston can pass or cover the vent in this cylinder.

When the pressure in the city or public system is greater than in the private one the gate valve will be automatically opened and the vent cock simultaneously closed, allowing water to flow in the private systems from the city mains until the pressure difference is reversed.

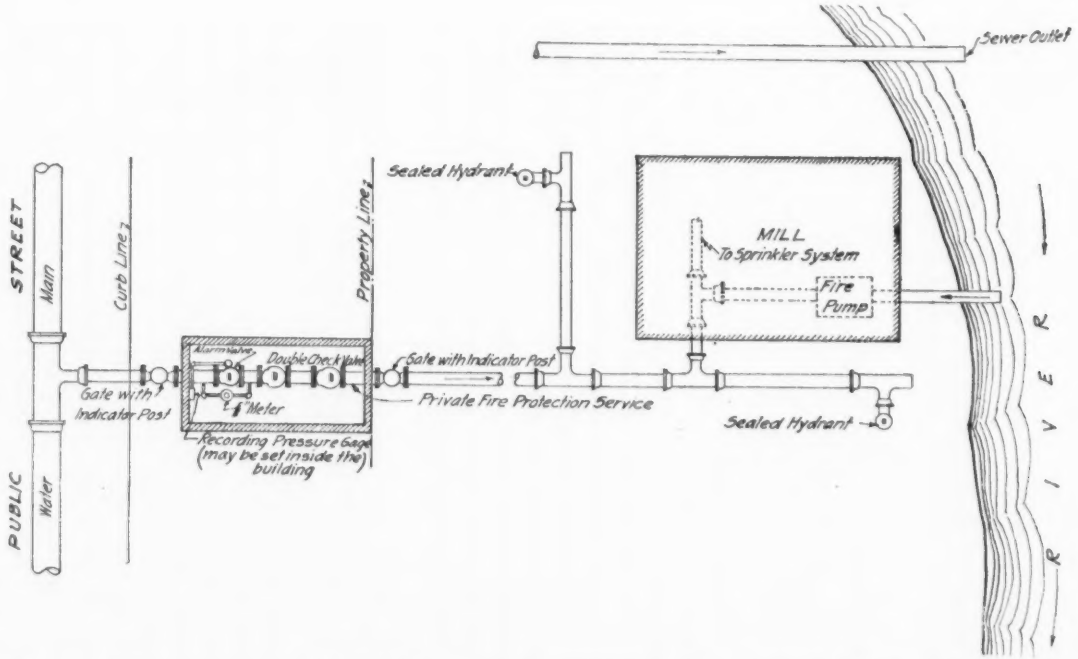


FIG. 11. ARRANGEMENT OF ALARM VALVE IN CONJUNCTION WITH DOUBLE CHECK VALVES FOR PREVENTION OF POLLUTION

Condition: (1) Building a safe distance from the public water supply main in the street. (2) Separate services are used for fire and for manufacturing purposes. (3) The sprinkler system is supplied by the public water supply and by an independent supply. (4) Regular and systematic inspection and testing of check valves and alarm valve, etc., is maintained.

ful quality are in use. Taking the public water to a cistern or tank above the flow line and delivering water to the fire protection equipment therefrom precludes the possibility of backflow.

SUMMATION OF PHYSICAL QUESTIONS

As a summation of their findings on the physical questions involved in private fire protection service, your Committee offers the following:

1. Water for domestic or commercial uses should be furnished through the same service pipe with water for private fire protection equipment for certain classes of consumers only. When a combined service for fire protection and other uses is allowed, a meter which will register all flows from the smallest to the largest, and of equal accuracy to the ordinary domestic and commercial meters, should be installed on the connection. In no case should a combined connection for fire service and domestic, commercial or manufacturing uses be allowed for mills, factories, large industrial establishments, or railroad terminals and yards.

2. No fire service connection should be installed without a fire service meter unless a system similar or equivalent to the Bond-Alarm-Inspection System, heretofore outlined, is adopted.

3. No private fire service connection should be installed without careful and adequate provision for properly located control valves equipped with indicator posts.

In congested districts, where property values are high and the finding of a safe and accessible location for the control valve is difficult, the installation of automatic or distant control is recommended as soon as a suitable device for this purpose is developed.

4. No service connection with a capacity in excess of 50 per cent of the water main supplying it should be installed. All risks requiring more than 50 per cent of the main capacity should be required to provide a supplemental water supply by storing water in elevated tanks or the equivalent.

5. Where an independent supply is used for private fire protection, the fire service connection from the public mains should discharge either into a cistern or elevated tank at or

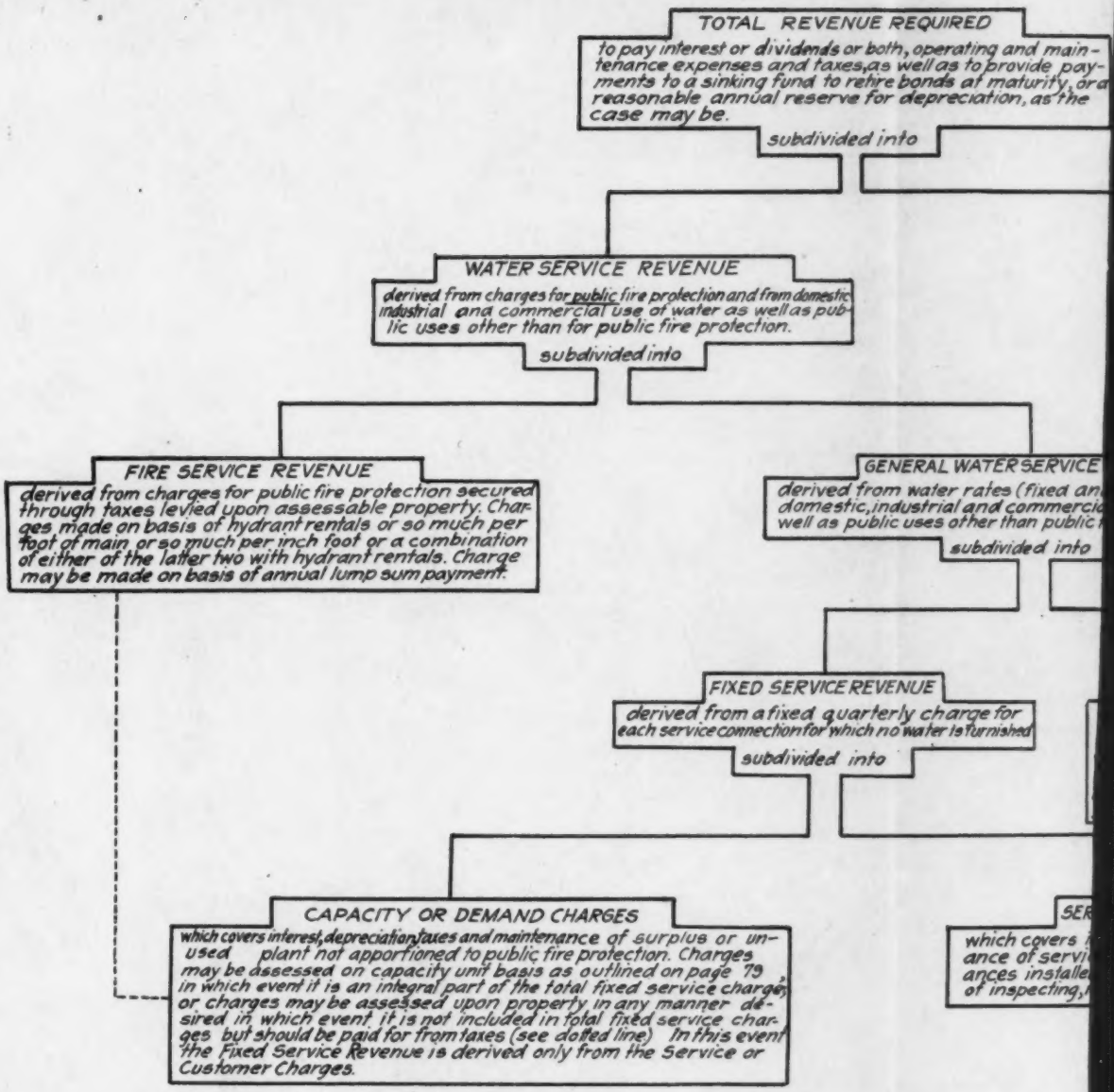

TOTAL REVENUE REQUIRED
to pay interest or dividends or both, operating and maintenance expenses and taxes, as well as to provide payments to a sinking fund to retire bonds at maturity, or a reasonable annual reserve for depreciation, as the case may be.
subdivided into
WATER SERVICE REVENUE
derived from charges for public fire protection and from domestic, industrial and commercial use of water as well as public uses other than for public fire protection.
subdivided into
FIRE SERVICE REVENUE
derived from charges for public fire protection secured through taxes levied upon assessable property. Charges made on basis of hydrant rentals or so much per foot of main or so much per inch foot or a combination of either of the latter two with hydrant rentals. Charge may be made on basis of annual lump sum payment.
GENERAL WATER SERVICE
derived from water rates (fixed an
domestic, industrial and commercia
well as public uses other than public
subdivided into
FIXED SERVICE REVENUE
derived from a fixed quarterly charge for each service connection for which no water is furnished
subdivided into
CAPACITY OR DEMAND CHARGES
which covers interest, depreciation, taxes and maintenance of surplus or unused plant not apportioned to public fire protection. Charges may be assessed on capacity unit basis as outlined on page 79 in which event it is an integral part of the total fixed service charge, or charges may be assessed upon property in any manner desired in which event it is not included in total fixed service charges but should be paid for from taxes (see dotted line) In this event the Fixed Service Revenue is derived only from the Service or Customer Charges.
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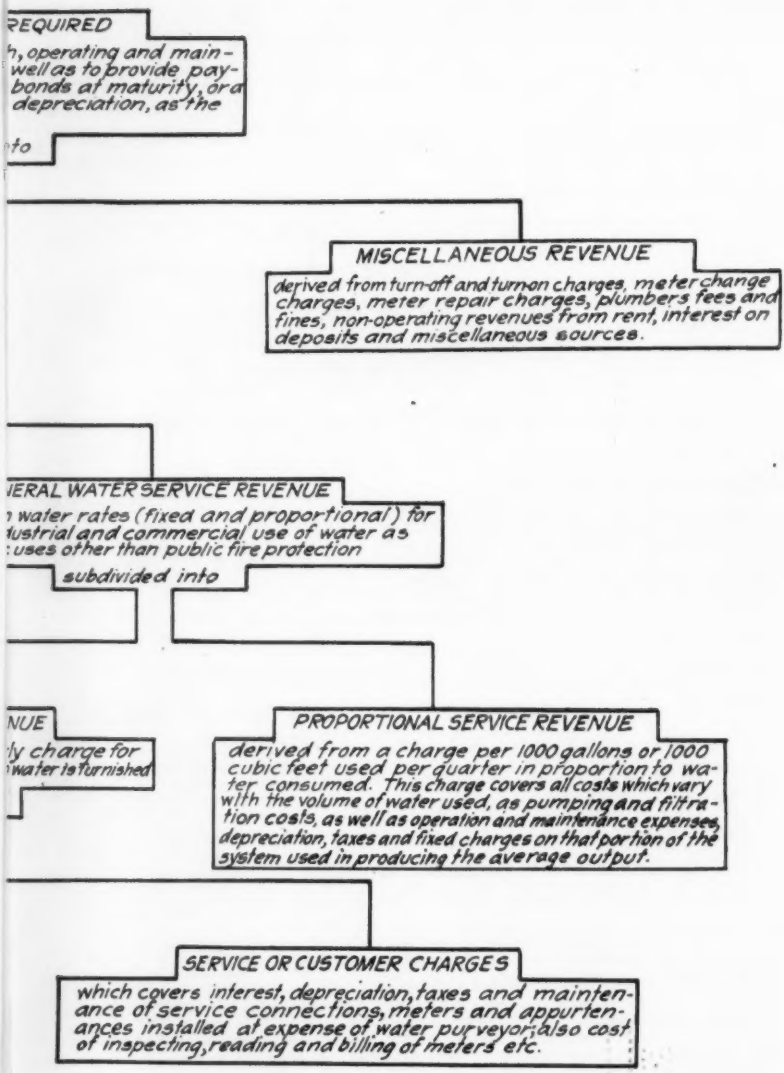
FIG. 12. DIAGRAMMATIC SUBDIVISION OF REVENUES AND CHAR


REQUIRED
h, operating and main-
well as to provide pay-
bonds at maturity, or a
depreciation, as the
to
MISCELLANEOUS REVENUE
derived from turn-off and turn-on charges, meter change charges, meter repair charges, plumbers fees and fines, non-operating revenues from rent, interest on deposits and miscellaneous sources.
ERAL WATER SERVICE REVENUE
water rates (fixed and proportional) for
dustrial and commercial use of water as
uses other than public fire protection
subdivided into
NUE
ly charge for
water is furnished
PROPORTIONAL SERVICE REVENUE
derived from a charge per 1000 gallons or 1000 cubic feet used per quarter in proportion to water consumed. This charge covers all costs which vary with the volume of water used, as pumping and filtration costs, as well as operation and maintenance expenses, depreciation, taxes and fixed charges on that portion of the system used in producing the average output.
SERVICE OR CUSTOMER CHARGES
which covers interest, depreciation, taxes and maintenance of service connections, meters and appurtenances installed at expense of water purveyor; also cost of inspecting, reading and billing of meters etc.

above the flow line and the protected property required to take water for the fire protection equipment from the cistern or tank to preclude the possibility of back flow.

When such an arrangement is not possible of attainment double check valves should be installed with proper means for inspection and testing as indicated on figure 7. Such valves should be regularly and systematically inspected, and reports filed as to their condition.

B. Fiscal Questions.

(6) By whom should the cost of installing the private fire service connections and accessories be borne?

It may be well to state at the outset of the discussion of fiscal questions that your Committee will deal only with general principles and that it makes no distinction between a municipal plant and a water company. A municipal plant and a water company have the same function, namely, to supply water, and should, therefore, be governed by the same practices and fiscal principles. In a municipal plant, the city is authorized by statute or by its charter to furnish its inhabitants with water, which it does through the agency of a committee, water board, or official in charge of the water department. In the case of a water company, the city is authorized likewise by statute or by its charter to furnish its inhabitants with a supply of water, and authorizes the water company to perform this function in substantially the same manner as the committee, water board, or official in the case of the municipal plant. In the matter of furnishing water to its citizens a city, when authorized by its charter, acts in a private rather than a governmental capacity, and should make the same reasonable charges for water that a private corporation should make when serving the public.

An unfortunate situation has arisen in municipal plants owing to a sad confusion of water revenues and revenues from taxes. In many municipal water departments the interest on bonded debt is paid from general taxation. In other cases, the water rates are so low that deficiencies in receipts from water rentals are made up from the general tax levy. In other words, there is no relation between the cost of supplying water and the water rates, and there

is no attempt to subdivide the cost of supplying water equitably between the water taker and the tax payer. As a matter of fact, a municipal plant should be made an independent, self-sustaining institution, properly credited with all revenues derived from the sale of water, whether to private consumers or to the municipality itself, and charged with all of the costs incident to such supply, including interest and sinking fund payments and operating and maintenance expenses. If this were done, the accounts of a municipal plant would be identical with those of a water works company and the charges for supplying water in a given locality substantially the same whether the plant were publicly or privately owned. If municipal water plants were made self-sustaining institutions, as private water companies must be, the public would soon come to realize that the choice between public and private ownership is not so much a question of cost of service as of the selection of the agency by which the service shall be rendered.

The term "service connection" in its broad sense includes all the piping leading from the main to the premises, including meters, stop cocks, valves, etc. No question has ever arisen with regard to the water utility paying for piping on the consumer's premises, that is, between the street line and the house. This must be laid at the owner's expense.

There has been much discussion of the question of whether the utility or the customer should bear the expense of installing the pipe in the street between the main and the property line. Upon this question the cases are in conflict, but it will be observed that the cases dealing with the question are comparatively recent. Formerly, the custom quite generally obtained of requiring the consumer to pay for the connection between the main and the property line. The great majority of cases hold that a water utility should install the service connection between the main and the property line at its expense, unless relieved of such obligation by some provision in the franchise or contract under which it engages to furnish water to the public. A few cases, however, have taken the view that in the absence of statute or franchise provision, a water utility may require the consumer to bear such expense. The majority of cases sustaining the right to require consumers to pay for service connections are for municipal water works and the decisions were based upon the construction of statute or charter provisions. As to the duty to repair, the majority of cases hold that the water

utility should keep the service connection in repair between the main and the curb, even where it was laid at the expense of the consumer. (Appendix 4.)

The water utility, whether public or private, should pay for the service connection from the main to the property line. The main and all laterals, fixtures and connections within the franchise limits belong to the utility and together constitute a water system, and it is not the business of the citizen or consumer to construct a part of the water system any more than it is the water purveyor's business to place pipes and fixtures on a consumer's premises. There is a clear and well defined boundary line existing between the property of the water utility and the property of the lot owner. That line is the one existing between the lot and the street or alley. The citizen owns his pipes and fixtures to that line and beyond it is the water utility's property and water system. These laterals are of as much use and as valuable to the water purveyor as are mains. The only difference between the laterals and the mains is with regard to the extent of the service. The capacity of a main is such that it will supply a number of consumers, that of the lateral sufficient to supply only one or two. The business of the utility is to deliver its product to the premises of the consumer. The utility and not the consumer has the right to occupy streets and all pipes laid in the streets should be the property of the utility and should be put in by the utility. The utility should have the undisputed and unquestionable right to maintain and operate, dig up and repair these connections without reference to any outsider.

From the financial viewpoint, the question of ownership is as broad as it is long, for if the utility only lays its mains in the streets it will, as a matter of course, have less money invested than if it carries its pipes to the property line of each individual consumer, and, therefore, will have less capital invested and will be entitled to a smaller return and will be compelled to charge less in the former case than in the latter. In other words, when the utility lays the service connections to the curb and owns and controls them, the rates should be made to pay interest and depreciation and the maintenance cost of such services.

With a rational system of rates and charges, there is no reason for making any distinction between private fire service connections and any other service connections. Your Committee is, therefore, of the opinion that the water utility should pay the cost of installing

the private fire service connection as far as the property line and that the charge for private fire service should be sufficient to cover interest, sinking fund charges and maintenance on the installation.

The public utility commissions have held in numerous cases that it is the duty of the public utility to install and maintain meters at its own expense upon the ground that the meter is a part of the plant or system which the utility should own. (Appendix 5.)

So far as the cost of installing the accessories, including control valves, check valves and alarm valve or meter is concerned, therefore, these devices should be owned and controlled by the water utility and, therefore, should be paid for by it and the fire service rate so fixed as to include a fair allowance for repairs and maintenance, and a reasonable return on these elements, as well as on the service connection proper.

(7) SHALL A CHARGE BE MADE FOR PRIVATE FIRE PROTECTION SERVICE?

The questions involved in determining a proper charge for public fire protection have been little understood up to a very recent date and proper charges for private fire protection still less so. Of late, however, the public utility commissions of various states have been called upon to distribute the charges for water service equitably. This condition of affairs has brought about an intensive study of the problem, with the result that much light has been thrown upon the situation. So far as the equitable distribution of charges is concerned, the decisions tend more and more to the establishment of the rule that free public fire protection is unfair to private consumers for the reason that the water taker is obliged to pay for privileges enjoyed by property owners, whereas the property owner should pay for this protection in proportion to the taxable value of his property. (Appendix 6.)

The decisions further indicate a growing tendency to allocate a larger proportion of the total cost of supplying water to public fire protection and thereby to make the taxpayer assume a larger share of the burden of expense for water supply purposes.

Now, who should bear the normal cost of furnishing private fire protection service? Admittedly, it must either be the one who takes this service, the other customers of the water utility who do not take this service, or the taxpayers of the community. It is also

pertinent to ask in this connection who benefits by private fire protection service, the water taker or the taxpayer?

It has been argued that the use of private sprinkler systems reduces the amount of water which otherwise would be used through the municipal fire apparatus. It has also been urged that private fire protection systems are a benefit to the community and ought to be encouraged by it. The insurance interests claim that the private hydrants and sprinkler systems are merely devices by which owners are able to apply water on their premises more efficiently and economically than through the usual public means, and they are thus supplementing and improving the work of the fire department; that ordinarily fire is extinguished with less use of water through private fire protection, and that the private fire protection system adds no burden upon the water works. The privately protected plant merely asks to be allowed to buy those tools which experience has shown make the use of public water possible with greatly increased effectiveness. For these various reasons it is argued that no charge, or a nominal charge, should be made for this service.

The argument that private fire protection service should be furnished free or at a nominal cost is fallacious. Private fire protection for individuals should not be secured through a rebate in the water rates and at the expense of other water takers, but by recourse to legislation making all property owners live up to rules and regulations which are compatible with the requirements of public safety. As the Public Utilities Commission of the State of Maine has put it in an opinion rendered in the Portland Water District Case:

> The proprietor of a manufacturing plant, or building filled with inflammable materials, or a place otherwise more than ordinarily exposed to dangers from fire within, has no more moral right to impose upon the community the added dangers incident to his particular business without taking recognized precautions to minimize the danger than to commit any nuisance forbidden by law. He has no more moral right to establish an excelsior factory in a city without taking inside fire precautions commensurate with the peculiar hazard attendant upon that business than he has to ignore the recognized precautions against the spread of a contagious disease. The owner of a fireproof structure in a wooden built section of the city would not expect relief from any part of the general tax burden because he had reduced the fire hazard. He would expect the owners of other buildings to comply with reasonable fire prevention rules at their own expense.

Blackstone in his famous commentaries on the law states that anything that worketh hurt, inconvenience or damage is a nuisance. The man who maintains a plant in the heart of a city which is potentially hazardous from fire maintains a nuisance unless he properly protects it, for such a plant or building worketh hurt.

A private individual may not use his property or his liberty in such a way as to do any substantial damage to his neighbors or to the whole community and he must conduct his business, however ordinary it may be, in a way that is reasonable.

The remedy for the fire hazard should not be looked for through free fire protection service, but through a proper reconstruction of the building codes and fire laws.

Even if it were admitted that private fire protection service should be given free, the cost of this service should not be distributed among other water takers, but upon the taxpayers. If the community, as such, and not as water purveyor, wishes to assume the burden of this class of service that is another matter, but the burden ought to be distributed by direct taxation in the same manner as a community does when offering tax-free land to induce manufacturing plants to locate within its confines. If the burden is borne by the users of other classes of water service, it is distributed according to the amount of service taken for other purposes and has no relation to the direct benefit conferred.

The reduction of the conflagration hazard and insurance rates on surrounding property is a property benefit and is not measured by the amount of water service taken by other water consumers. If the installation of sprinklers is to be rewarded by an exemption from tolls because it is a benefit to other property, the property benefited ought to be made to assume the shifted burden. Its refusal or neglect to do so does not justify putting it on those consumers who neither own sprinklers nor benefit by their installation.

In weighing these arguments, it should be remembered that in 30 per cent of the fires in sprinklered risks the fire department is called into play, and also that the installation of private fire protection systems, where they do not extinguish incipient fires, may add a heavy drain upon the public piping system and thereby jeopardize the public fire protection. The danger of a large waste of water inside a protected property in the event of a destructive fire, due to connections to it, is very great. It is difficult to locate valves

where these connections may always be shut off when they have ceased to do good and they commence to do incalculable harm. Usually what is wanted in a fire protection system is a reasonable amount of water at an effective pressure. Sometimes what is demanded is an unreasonable amount, which means that not alone the sprinklered risk but surrounding property is endangered, and the water withdrawn is used to no good purpose.

No one who realizes the manifold problems which private fire protection service develops can for an instant doubt that the water purveyor assumes not alone responsibility and cost but possible liability in rendering such service. The furnishing of private fire protection service by a water utility is one of its legitimate activities and constitutes an important part of the service it is intended to render. This service can no more be rendered without the existence of a completed plant than any other service can. The plant investment, upkeep and operation are as essential to this as to any other. There is no reason for making a distinction between this and other classes of service rendered by the utility. None should be exempt from carrying its fair proportion of the whole burden. There is no more reason for exempting the takers of private fire protection service from meeting their proper share of the total cost of service than for exempting other patrons of a water utility.

Two things must be considered in establishing a fair basis for a charge for service, first, the cost of the service, and then the worth of the service to the consumer. The consumer is entitled as a matter of right to adequate service at reasonable rates under reasonable conditions and to pay no more than the worth of the service.

It has been demonstrated that private fire protection service entails cost. The one question remains, then: Has this service worth to the one who takes it? In answer to this question we will quote from the testimony of the insurance experts in the Portland Water District Case previously referred to. From this testimony we find that the introduction of a private sprinkler system resulted in one case in a reduction from $2.04 per $100 of insurance to 34 cents on one section of a plant and to 40 cents on another. The Portland Stove Foundry carried in excess of $100,000 of insurance as an unsprinklered risk. Its rate was $1.70 per $100. As a sprinklered risk it was 22 cents per $100, a saving in insurance of $1,480 per year, which capitalized at 5 per cent is equiva-

lent to $29,600. The installation and maintenance of private fire protection systems entail cost, so that the difference as shown above is not all net saving, but in the majority of cases the reduced rates pay for the fire protection installation in from five to eight years. The saving effected by the installation of these systems is very much lager than the cost and it should be borne in mind that these figures take no account of the saving effected by insurance against interruptions to business not compensated for by the kind of insurance herein discussed.

With relation to decisions affecting private fire service protection, there is an apparent unanimity of opinion by courts and public utility commissions, to the effect that a water utility which supplies water for private fire protection purposes performs a service which is in addition to supplying water for public fire protection, and the water utility has a right to make a reasonable charge for private fire protection service. (Appendix 5.) In the case of Gordon and Ferguson vs. Board of Water Commissioners, (100 Minn. 343; 111 N.W. 272; 8 L.R.A. (N.S.) 1049), the judge said:

> So long as the water supplied for protection against fire is a purely public service under the control and management of the municipal authorities generally, and under the fire department specifically; no direct charge to individuals is proper. When, however, a sprinkler connection is made with private premises the situation is materially different. These premises and the primary causes of catastrophe to the building and the consequent possible use of disastrous quantities of water are primarily under the control, not of the public, but of the owner. A peculiar personal service is provided for the owner's benefit, which is not enjoyed in common by the community in general, but is available only to a limited class of individuals. As a matter of good sense the property owner beneficially employs the water mains for his own purposes and to his own advantage, although he may not, except in case of fire, actually draw any water from the pipes. It is necessary and proper that he should pay. In effect, he gets something of pecuniary value from another, which that other is not compelled to give except on the basis of contract. The conclusion is reached that a charge can be made.

The service required of a water utility is of two classes:

1. Readiness to serve a large quantity of water at irregular and indeterminate intervals whenever called upon.
2. A constant supply of water with comparatively slight variation in the amounts called for.

The private fire protection consumer falls into the first class. What he requires is a connection of large capacity through which

a small amount of water is ordinarily taken, but which may be utilized to full capacity at infrequent intervals. His needs are distinct from those of the ordinary domestic consumer who requires a quantity of water continuously and substantially proportional to the capacity of his service connections. In the case of one we have capacity cost, in the other production cost. Since the cost of service should not be shifted from one source to another in the rates, it follows that the consumer who requires the utility to incur capacity costs should not put the burden of paying for them upon the consumer who does not want capacity but wants water. Under the circumstances, therefore, your Committee has no choice but to recommend that a charge for private fire service connections be made.

(8) HOW SHOULD THE CHARGE FOR PRIVATE FIRE PROTECTION BE DETERMINED?

In attempting to outline the method of establishing a system of rates, it may be well to remark at the outset that the existence of a mixed schedule for metered and unmetered water service greatly complicates the problem of distributing the cost of water between consumers. There is no basis for establishing a rational system of flat rates. Such a scale of rates is at best a makeshift, and one man's guess is as good as another's. A system of flat rates is based upon estimates. Such estimates are formulated on widely different plans, such as the number of fixtures, rooms or persons in the house, the floor space, or the height of the house, the number of feet front which it occupies, or the purpose for which water is used. Such schedules are of necessity incorrect and work unevenly, requiring consumers under certain conditions to pay but little, and under other conditions to pay exorbitantly for the water they use. The water works system that attempts to work on a flat rate schedule cannot possibly do even approximate justice between its consumers. Under these circumstances, your Committee has not attempted to suggest a method of ascertaining a proper charge for private fire protection service where flat rates are in vogue.

The fact that it would be impossible for this Committee to establish a rate for private fire protection service is too apparent to need mention. Rates vary with the cost of service. The cost of service varies with local conditions, and, therefore, the rate for one situation

would not necessarily be the rate for another. All that can be done is to outline a method by which it will be possible to establish an equitable rate for private fire protection service. In doing this, your Committee fully recognizes that there are differences of opinion with regard to the allocation of costs to produce equitable rates. There are certain general principles, however, upon which courts, commissions, and water purveyors seem to be agreed, among which may be mentioned:

1. The cost of service should be equalized between the water taker and the taxpayer and heretofore the water taker has frequently been assessed more than his just share of the cost of water service, due largely to the fact that an insufficient amount of revenue has been derived from public fire protection service.

2. Public fire protection service is a property benefit and the cost of this service should be assessed upon the property owner or taxpayer and not upon the water taker.

With much reason some advocate going a step further by assessing all costs attributable to excess plant, whether installed for fire protection or to meet future development or extraordinary demands, upon the taxpayer. That is, to assess the taxpayer for the interest, depreciation and maintenance of all plant required beyond that to meet the ordinary maximum daily consumption for domestic, industrial and manufacturing uses. The theory of allocation is the same in principle, whether the excess due to fire protection alone or both are included in the general tax levy. The difference is one of degree to which the taxpayer is assessed for his proportion of the cost of supplying water. In practice, it will be found that if the costs attributable to the plant necessary for public fire protection, or to that portion of the plant which it would not be necessary to install in the absence of public fire protection service, are levied upon property and not upon the water taker, the theory of assessing all surplus capacity upon the property owner will be substantially complied with.

3. It is generally conceded that the revenue to be derived from general water service, that is, the revenue derived from domestic, commercial, manufacturing and public consumption

for other than fire protection purposes, should be subdivided between fixed service charges and proportional service charges.

4. There should be no free water, not even for municipal or public purposes other than fire protection.

The principles which apply to establishing fair rates may be stated as follows:

1. Fair and equitable rates must cover all of the operations of the water utility.

2. The division of the rates among the consumers must be such as to give no undue preference to one class of consumer over another.

3. In determining how the rates should be divided, the cost of the service required by each class of consumer must be determined, and the entire cost, so far as possible, divided among the different consumers who take different classes of service.

Bearing these facts in mind, your Committee will attempt to outline but one method of allocating charges, for by so doing much confusion will be avoided. The method chosen complies substantially with the system of rates which has been adopted by the Public Utility Commissions of New Jersey, Pennsylvania, Maryland, Wisconsin, and possibly other states.

The problem of establishing fair rates may be broadly stated as follows: Every water works plant, municipal or private, has a certain sum of money invested upon which it must pay interest or dividends, or both. In addition, it must set aside an annual reserve for depreciation, or pay annually into a sinking fund an amount sufficient to retire its outstanding bonds at maturity. It must also pay operating and maintenance expenses and taxes. If the property is exempt from taxation, taxes need not be included in the gross revenue required, but the principle is the same. If the plant is self-supporting, these expenses must be paid for from the revenues of the water works, whether municipal or private. The revenues must be derived from the rates if justice is to be done to all.

The problem of devising a schedule of rates which distributes the cost equitably among all classes of consumers involves two main operations, therefore:

A. Determining the gross revenue required to provide interest or dividends, or both, plus a proper allowance for operating expenses, taxes, and a reasonable annual reserve for depreciation or sinking fund charges as the case may be.

B. Establishing the incidence of the rates by:

1. A fair separation of the area served by the water purveyor into districts if, under the conditions of service existing in the plant, certain consumers possess the advantage of location, whereby the cost of delivering water to some is less than the cost of delivering water to others. Such a separation of area is not necessary if an average rate for the entire area may be used.

2. Subdividing the gross revenue between:

   a. Miscellaneous revenue.

   b. Public fire service revenue.

   c. Revenue derived from the sale of water to domestic, commercial, manufacturing and public consumers.

3. Subdividing the revenue derived from the sale of water between proportional service costs and fixed service costs.

4. Subdividing proportional service charges for water supplied between the classes of consumers as a means of establishing a sliding scale of rates, if desired, which varies with the cost of supplying water in different quantities.

Proportional costs are kinetic costs, which vary closely with the amount of the production or output or the amount of water consumed and, therefore, include the production or output costs. The cost of pumping and filtering is in large measure a production cost and all operating and maintenance expenses on the used capacity of the distribution system should be charged to proportional cost.

Fixed service costs are the static costs which do not vary with the quantity of water produced. Fixed service costs are composed of two elements:

1. The demand, capacity or readiness to serve cost.
2. The service or customer cost.

The capacity or demand costs do not vary with the output, but with the capacity which a plant must have to meet the demand without regard to the amount of water consumed. In every plant sufficient capacity to meet the maximum demand which the water

utility has contracted to supply when called upon to do so must be provided in addition to the capacity necessary to meet the ordinary and usual daily demand. The plant necessary to meet the spasmodic or unusual demand lies idle for a large portion of the time. The capacity chargeable to the capacity or demand cost is the surplus capacity of the system not apportioned to fire service, which represents the capacity required to meet unusual or spasmodic demands or to provide reasonable future development. The capacity or demand cost is, therefore, chargeable to plant made necessary to meet the contractual obligations of the water utility to furnish this demand and is in substance a readiness to serve charge. The courts and public utility commissions have recognized the propriety of a readiness to serve charge. (Appendix 6.)

In addition to the capacity or demand costs, service or customer costs must be provided for. These costs result directly from individual service rendered to the customer. They include interest and depreciation, or sinking fund charges, on the cost of the service connection and meters if the cost of installation is paid for by the water purveyor. They include the cost of reading meters, of rendering and collecting bills, of repairs to service connections, meters and appurtenances, and in the case of private fire protection service, special inspection expenses. Such costs would not accrue if the plant existed in its entirety without consumers.

The total fixed service charge is the sum of the service or customer cost and the capacity or demand cost. Both of these costs vary generally with the size of the service connection or meter. While this is not a precisely accurate statement, it is, broadly speaking, true, and it must be remembered that what is wanted in a system of rates is not mathematical precision but simplicity, and it is necessary to make some approximations in order to arrive at a simple rate schedule.

A correct analysis of service costs clearly indicates that the separation of fixed service costs and proportional service costs is not a subtle distinction, but a rational separation based on the fundamental principle of assessing the fair cost of the service to each consumer. One consumer may desire a connection of large capacity through which a small amount of water is ordinarily taken, but which may be utilized to full capacity at infrequent intervals, whereas another may consume water in quantities reasonably proportional to the size of his service continuously throughout the year. Why

should the latter pay for the utility's readiness to serve the former? The readiness to serve bears a direct relation to the size of the plant and, therefore, to the fixed investment in the property necessary to give service on demand.

The gross revenue, which it is necessary to derive in order to secure interest plus a proper allowance for operating expenses and taxes and a reasonable annual reserve for depreciation or sinking fund charges, is derived from two main sources:

1. Revenue derived directly from water service, or the sale of water, which includes the revenue derived from public fire protection, as well as that derived from domestic, industrial, commercial and manufacturing, or public uses other than fire, and

2. Miscellaneous receipts which include revenue from turn-off and turn-on charges, meter change charges, meter repair charges, plumbers' fees and fines, and non-operating revenues derived from rent, interest on deposits, and other miscellaneous sources.

The principal steps in the establishment of a system of rates may be outlined as follows:

	per cent
A. Subdivide the total required revenue between water service revenue and miscellaneous receipts:	
Miscellaneous receipts	
Total water service revenue	
B. Subdivide the total water service revenue between fire service and general water service revenue:	
Fire service revenue	5 to 50
General water service revenue	95 to 50
Total water service revenue	100 to 100
C. Subdivide general water service between revenue from fixed service charges and revenue from proportional service charges:	
Fixed service charges	20 to 40
Proportional service charges	80 to 60
Total general water service revenue	100 to 100
D. Subdivide fixed service revenue between capacity of demand cost and service or customer cost:	
Capacity or demand cost	20 to 50
Service or customer cost	80 to 50
Total	100 to 100

The limits between which the charges for the different classes of service vary when properly allocated are too great to admit of suggesting a definite percentage chargeable to each, but the limits between which such charges vary, expressed as a percentage, have been given as a guide to the general problem of fixing rates.

The subdivision of charges between districts has not been attempted, for if the gross water service revenue which should be derived is properly subdivided between districts, the problem of allocating charges between different classes of service within a district is identical with the outline here given for the plant as a whole.

It is not the purpose of this report to go into the details of the method of making a fair apportionment of the revenues between public fire service protection and general water service. This matter has been fully discussed in a paper by Messrs. Metcalf, Kuichling and Hawley (*Proceedings*, American Water Works Association, 1911, page 55). Reference is also made to the determination of the value of fire protection afforded by the Queens County Water Company by Joseph Goodman (*Proceedings*, American Water Works Association, 1916, page 450). It is only necessary to say that the apportionment of costs to public fire service varies greatly with the size of the plant, the cost of public fire protection service being relatively much greater in small plants than in large plants.

Having ascertained the proper amounts to be collected from public fire protection and from general water service, the next step is to deduct the revenue derived from public fire protection from the total water service revenue, and apportion the remainder, or the general water service revenue, between revenue to be derived from fixed service charges and from proportional service charges. The ratio of fixed service charges to proportional charges varies somewhat in different plants, but, in general, the fixed service charges fall between 20 and 40 per cent of the revenue to be derived from general water service, which, of course, means that the proportional service charges vary between 60 and 80 per cent of the same amount.

The theory on which operating expenses and fixed charges are divided between proportional and fixed service charges is that the direct expense of materials and supplies, as well as interest and depreciation or sinking fund payments on that portion of the plant which is utilized in producing and delivering the commodity supplied, should be included in the proportional charges. The proportional charge covers the cost of producing and delivering water for

the normal service requirements, and includes collecting and storing, pumping, filtering, transporting and distributing. In this way, coal and wages at a pumping station, chemicals and wages at a filter plant, and that proportion of the maintenance and care of the pumping station and filter plant, the distributing reservoirs, distribution system, and storage reservoirs, which is chargeable to actual output goes to the proportional charge for water.

Since the proportional charge varies with the quantity of water taken, the basis of charge should be so much per hundred cubic feet, per thousand cubic feet, or per thousand gallons.

The capacity costs are the costs chargeable to the excess plant made necessary to meet the contractual obligations of the company to furnish the maximum demand which the water consumer may make. Thus, the fixed charges on the reserve portion of the pumping stations, filter plants, impounding reservoirs, mains, etc., is chargeable to capacity cost. The material, labor and interest appurtenant to the reserve capacity should be charged to the capacity or demand cost.

The total fixed service charge for domestic, commercial, industrial and public uses other than fire, which is the sum of the capacity and consumer cost, should be levied as a fixed annual amount to be paid quarterly whether water is taken or not.

The fixed service charge may be based upon a capacity unit. The capacity unit has in a number of cases been fixed as the capacity of a $\frac{1}{2}$-inch service connection or $\frac{1}{2}$-inch meter. By ascertaining the capacity ratio between a $\frac{1}{2}$-inch service connection or meter and other sizes of service connections or meters, the number of capacity units in each size of service connection or meter may be ascertained. If all of the service connections or meters in a plant and their sizes are listed, the total number of capacity units in the system may be ascertained and the net unit fixed service charge will be the quotient of the total revenue which should be derived from the fixed service charge divided by the total number of capacity units in the water works system. By multiplying this capacity unit charge by the ratios established for the different sizes of service connections or meters, the fixed service charge for each size of connection or meter may be ascertained.

If it is desired to assess more than the cost of public fire service upon the taxpayer, the fixed service charge may be subdivided by assessing that portion of the charge due to excess capacity directly

upon the property benefited, on any basis desired, and the remainder may be levied upon the water taker on the capacity unit basis above outlined.

Modifications in this respect may be made in individual cases to suit individual preferences, but the principle is the same. Attention should be called, however, to the advantage of establishing a uniform system of water rates and of following practices which commissions regard as according substantial justice to all.

By deducting the revenue from the fixed service charges from the total revenue to be derived from general water service, the amount to be derived from proportional charges for water used may be ascertained. When this is done, ascertain the total net pumpage, that is, the total pumpage less water unaccounted for due to pump slippage, leakage in mains, etc., and divide the total revenue to be derived from proportional changes by the total net water delivered to ascertain the rate per unit of water sold.

With such a system of rates established, it is simple to see that one who requires a large service connection and little or no water will pay only the fixed service charge, whereas one who requires a small service connection and a steady supply of water will pay for the bulk of his service through the proportional charges. As one of the members of the Maryland Public Service Commission said, you buy water on the European plan. One pays so much for his room, and pays in addition for whatever he takes to drink. It is also simple to see that the charge which will be made for fire protection service under such a system of rates will be the fixed service charge, which will be the same as would be charged for any other connection of the same size without distinction or discrimination on account of the purpose for which the connection is desired.

The following rules should be considered in conjunction with the establishment of a system of rates of this kind.

> When the word "consumer" is used it is used to designate the party contracting for or using service on a premise.
>
> When the word "premise" is used it shall be taken to designate:
>
> a. A building under one roof owned or leased by one party and occupied as a residence, or for business or commercial purposes, or

b. A group or combination of buildings owned or leased by one party, occupied by one family, or one corporation or firm, or as a place of business, or for manufacturing or industrial purposes, or as a hospital or other public institution, or

c. One side of a double house having a solid vertical partition wall, or

d. A building owned or leased by one party containing more than one apartment and having one entrance and using one hall in common, or

e. A building owned or leased by one party having a number of apartments, offices or lofts which are rented to tenants, or

f. A public building such as a town hall, school house, fire engine house, etc., or

g. A single lot or park or playground, or

f. Each house in a row of houses.

When the term "service connection" is used it is intended to mean the pipe line from the water main to a premise.

Where more than one service connection is used for one premise, or for one consumer, the fixed service charge shall be applied to each and every connection supplying one premise or one consumer.

Where two or more service connections supply the same premise or the same consumer, the consumer shall be billed at the schedule of proportional rates for a quantity of water equivalent to the sum of the readings of all meters on the premises.

Private fire hydrants shall be charged for at the same rates as public fire hydrants.

Respectfully submitted,
NICHOLAS S. HILL, JR., *Chairman.*
GEORGE G. EARL,
FRANK C. JORDAN,
WALTER E. MILLER.

Owing to the absence of Major French in Europe the Committee was unable to submit the report to him for final review and acceptance, and reservation has been made by the Committee for Major French either to sign or submit a minority report.

APPENDIX 1*

Relating to the Use of Water Through Private Fire Service Connections for Other than Fire Purposes

The Committee sent a circular letter to the members of this Association requesting information with regard to their experience relating to the use of water through private fire service connections for other than fire purposes. This letter was sent to 900 individuals, most of whom are water works superintendents or directly connected with the operation of water utilities. In response to this letter 521 replies were received. A summary of the data contained in the replies received follows:

a. Two hundred and thirty-six testified to instances where water was drawn from private fire protection services for other than fire use, or where a decided leakage or waste of water had been discovered on such connections.

Extracts from these replies follow, which your Committee believes will be illuminating on account of the variety of the experiences recorded.

b. Twenty-eight reported that no private fire service connections were installed unless metered, and hence the use of water for other than fire purposes was paid for by registration of the meters.

c. Eighteen stated that there were no private fire protection services on the water system

d. One hundred and eleven gave no information one way or the other, or were ambiguous.

e. One hundred and twenty-eight stated that no case of the use of water through private fire protection services for other than fire purposes had been encountered. Some of these replies stated that the water system had only two or three unmetered fire protection services which made inspection of them simple. In other replies it was difficult to determine whether such services were metered or not, or whether the system included any private fire service connections. They have all been included, however, in the category of negative answers.

The positive responses indicating the use of water through private fire protection services for other than fire purposes come from cities and towns in almost every part of the United States and Canada.

Case 1. Private company in city of about 5000 population forced into receivership through heavy surreptitious use of water through private fire protection lines, which increased the known uses of water about 50 per cent.

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* The appendices are printed in an abridged form. Copies of the complete text have been placed in the hands of the Secretary, who has been authorized by the Publication Committee to lend them to the members for periods not exceeding two weeks.

Case 2. Many cases known, about one being discovered each month; usually due to connections made by plumbers or mechanics without knowledge of owners.

Case 3. Succeeded in collecting $2000 for surreptitious use of water through a private fire protection line.

Case 4. "A water company, serving a community of about 4500 people, supplied about 480,000 gallons of water per day. On a visit to the town the company's engineer concluded that this consumption was altogether too high for such a place, as other places having the same characteristics used about half that amount of water. A waste water investigation was made and it was discovered that almost one-half of this pumpage went unmetered through the private fire protection lines of a bleachery in the town. This bleachery was paying about $200 for one-half the pumpage and fire protection service, whereas the rest of the town was paying $14,200 for practically the same amount of water less fire protection service. When this fire protection line was metered, the water company was able to make a $40,000 capital expenditure for improvements, including standpipe, filter plant, extensions to force mains, etc., and still remain solvent, whereas before its financial standing had been precarious."

Case 5. Factory sometimes took the entire supply to the town during the night, leaving the rest of the community without water for fire protection; this was done surreptitiously through an unmetered fire protection line attached to street mains fed by a gravity supply.

Case 6. Many cases of surreptitious use discovered by uncovering all private fire protection lines.

Case 7. Experience with metered fire protection lines shows that leakage may cause very large losses, apart from uses for legitimate purposes.

Case 8. Metering the entire supply to a large industrial plant instead of relying on 18 small meters to the buildings revealed a draft of twice as much water as the small meters indicated. This led to the discovery of large leakage from the private pipes and eventually resulted in a much reduced draft by the plant and an increase of about 100 per cent in the water bills.

Case 9. Over half of the unmetered private fire lines were found to be used surreptitiously, in one case to the amount of 500,000 gallons daily, so that unmetered services of this class are no 'onger installed.

Case 10. Surreptitious use of water from the private fire protection line to a large plant caused a serious shortage of water in the town for three days, before the cause of the trouble was discovered.

Case 11. Many cases of surreptitious use discovered despite rigid inspection costing about $6000 annually.

Case 12. One concern took 1,500,000 gallons through its fire service without paying for it.

Case 13. Hardly a day passes without the discovery of surreptitious use. Eliminating it in one town caused a reduction in the pumpage of nearly 50 per cent.

Case 14. Three instances known.

Case 15. Many cases of surreptitious use of water from unmetered private fire protection lines known; present practice is to meter all such services and

the meter readings show that large underground leakage is likely to occur on the private pipes.

Case 16. Factory boiler supply taken surreptitiously from unmetered private fire protection sprinkler line.

Case 17. One instance reported.

Case 18. Instance of surreptitious use of water from sprinkler system to fill dye and wash tubs of shoddy mill.

Case 19. Numerous instances of connections made surreptitiously by mills with their private fire protection lines to supply dye and wash tubs, slush pipes and such fixtures.

Case 20. "I could quote you any number of cases where we have found use of water from fire lines—some intentionally, maliciously and with forethought, others where the distribution system of the consumer was improperly laid and the leakage therefrom did not appear on the surface but found its way underground on the premises. Then again, in the ramifications of the piping of a large manufacturing plant, the domestic and commercial services are very often interconnected in the plant, which will allow water to be taken through the fire service under certain conditions.

"In a large manufacturing plant the plumbing and attachments to water mains are often laid without attention to the existing contract between the Water Company and the consumer—not with any intention to take water without payment, but the man who usually does this work is not familiar with the stipulations in the contract and very often does not realize that this piping that he attaches connections to should not be used for any other purposes than fire protection.

"The leakage due to distribution to consumers is very often a very material item and if there is fire protection, such as sprinklers or stand pipes, located on the property, they very often overflow and the Water Company receives no payment therefore. Then again, in case of emergency, it is very easy for a consumer to attach a hose to a fire hydrant for temporary use and no report is made to the Water Company."

Case 21. Water used surreptitiously for washing out boilers.

Case 22. Metering private fire lines has detected leaks which would have been undiscovered otherwise.

Case 23. Fire hose used for washing moving picture theater.

Case 24. Fire hose connected to private lines frequently found used surreptitiously for washing floors and other purposes. Instance of sprinkler head being replaced by faucet.

Case 25. Surreptitious use of water from unmetered private fire lines to railways, street railways, newspapers, factories, business houses and mills has been discovered.

Case 26. Three instances known.

Case 27. A small factory paying $137 annually for unmetered fire service was found to be using and wasting a very large quantity for other than fire protection purposes.

Case 28. Reports knowledge of many cases of surreptitious use of unmetered water by industrial concerns.

Case 29. "A subsidiary of one of the largest corporations in the country had a factory on a large river. They had a pump installed on the river bank, and they claimed to pump their own water. Pressure for a complete sprinkler system and for two fire plugs was secured from a water company. The factory was surrounded on three sides by a very high board fence. There was no fence along the river bank. The industry used a considerable quantity of water. It was noticed that the factory did not shut down when the river flooded their pumping station out.

"The sprinkler system was frequently inspected, but careful inspection did no show any improper use of water. The superintendent and all the workmen were sure that there was no possibility that city water was ever used in the plant. After a time, they rather welcomed inspection, seeming quite proud that they had covered their tracks so well.

"A disgruntled discharged employee finally gave helpful information. We found that the location of the plant was such that we could meter them without their knowledge. We installed a recording gauge and a 4-inch meter in a 'friendly' building several hundred feet away from the 'unfriendly' plant. We then took careful notes of the pressures, consumption and also of the operation of the pump on the river.

"One morning the writer hurried to the factory and told the superintendent that we must shut the valve on his line, which valve was just outside his fence. He was much confused, feeling sure that such action would blow out his sprinkler heads. However, the valve was being shut before the writer entered the factory. When the valve was shut, the pressure gauge showed no change but the meter stopped running. When our observer on the other side of the river reported that the pump on the river bank appeared to be running very well, we hurried up and opened the valve outside the fence. The pressure gauge picked up a little and the meter ran backwards.

"We had previously been informed that the pump on the river had no connection with the sprinkler system nor the fire plugs. We did not notify the factory of our discovery but waited developments. In a short time the company asked us to furnish them with water for manufacturing purposes. We then presented them a bill for water used without contract. Failing to collect, we entered suit. The case came up for trial. Our testimony completely surprised them. They immediately proposed that the case be settled out of court. The jury was not a very pretentious collection of individuals. In the section of the country where the case came up private water companies do not receive the popular sympathy to which they are justly entitled. We therefore settled out of court. The theft had been going on for several years."

Case 30. Reports surreptitious use of about 750,000 gallons a month to operate a hydraulic elevator.

Case 31. Reports knowledge of numerous cases of surreptitious use.

Case 32. Reports use of water to extinguish fire in coal pile which burned for a long time. "It has been our contention that the real purpose and intent of a private fire protection system does not embrace the right to use continuously for months water to provide against loss in efficiency in coal."

Case 33. Reports knowledge of four cases of surreptitious use.

Case 34. Reports surreptitious use of water from fire protection system for boiler feed.

Case 35. Cannot recall any unmetered fire protection services which, on thorough investigation, did not reveal use of water for purposes other than fire protection.

Case 36. Drinking fountains in moving picture theatres supplied from unmetered fire protection services.

Case 37. Water from unmetered fire lines used to wet down cinders.

Case 38. Reports discovery of a leakage of 1000 cubic feet daily in a priming connection; revealed by metering.

Case 39. Believes that water is used surreptitiously from all unmetered fire services. The smallest bills rendered after metering such connections have been about $50 a year.

Case 40. Believes that surreptitious use of water from unmetered private fire services is generally made by employees without the knowledge of their responsible superiors.

Case 41. Reports considerable experience in detecting surreptitious use of water. Calls particular attention to such a case where locomotive tenders were filled from a hydrant when the metered connection for that purpose was in use for a locomotive.

Case 42. "I beg to advise that at least one serious case of this kind was found several years ago in this city. The party obtaining the water was billed for the amount, which was quite large, and paid the bill. At that time detector meters were put on about one dozen manufacturing plants similarly equipped with unmetered fire services. Since then, however, there has been no further extension of the detector meter system on account of the strong opposition led by the Factory Mutual Fire Insurance Companies on several occasions afterward when this matter has been brought up. . . . . For your information I would also say that readings of the detector meters show that in some of the plants where they are installed quite large quantities of water are recorded monthly, although the insurance companies assure us that they allow no connections with fire supply services."

Case 43. Reports installation of 35 meters on private fire protection services, about half of which showed more or less regular use of water, although the services were installed for fire protection solely.

Case 44. Reports numerous cases of surreptitious use of water, four within the last six months.

Case 45. Recently discovered a 2-inch boiler feed line tapped to a 6-inch unmetered fire service.

Case 46. "The first sprinkler system installed in this city was not metered and the water department was to furnish water free for fire protection. We were assured by the owners that there would be no water used through this line except for fire purposes and the insurance representatives informed us that the insurance would be immediately cancelled if this agreement was not kept. . . . . A few months later a discharged employee tipped us off that the factory was using water for their boilers and other purposes. . . . . We found this to be a fact and since that time have accepted no sprinkler risks except on a meter basis."

Case 47. Surreptitious use of water by a railroad company for several purposes.

Case 48. Reports two cases of surreptitious use, one amounting to about 1,000,000 gallons daily, and numerous cases of leakage from private mains, which it was necessary to meter before the owners would repair them.

Case 49. Reports many cases of breakage of seals on private fire services where there had been no fires.

Case 50. Unmetered sprinkler system tapped for boiler feed.

Case 51. Reports knowledge of several cases of surreptitious use of water from unmetered fire protection services.

Case 52. Connections made by employees to the drain pipes of sprinkler lines as the easiest method of securing water for industrial uses.

Case 53. Surreptitious use of water from fire hydrants in the yards of a large manufacturing plant, chiefly to fill locomotive tenders.

Case 54. A private fire hydrant was tapped by a 2-inch connection furnishing water surreptitiously to a blacksmith shop of a large car shop, and locomotive tenders were filled from fire hydrants.

Case 55. Water from an unmetered private fire service used for boiler feed.

Case 56. So many cases of surreptitious use of water from private fire services were discovered that all such lines are now metered.

Case 57. "In one case in particular, a large furniture factory, we obtained conclusive evidence of the surreptitious use of water and were proceeding to meter their fire service line when an injunction was issued restraining us from so doing. Upon trial of the case, when the facts were brought out, the Court decided that we were well within our right in metering it, but as no issue was before the Court other than that of attaching the meter to the fire line, the actual question of appropriating water without payment was not decided. A bill rendered the factory, based on estimate, was, after the Court decision, settled by the payment of a substantial sum."

Case 58. Reports four cases of surreptitious use. In one of them $50 was collected and in another $200 for water used without permission. Formerly private fire hydrants were sealed, but nearly every month a number of seals were found broken.

Case 59. Boiler feed drawn from unmetered fire protection service.

Case 60. Water used from an unmetered fire service for moistening wheat in a flour mill and for washing out boilers.

Case 61. Water from unmetered sprinkler line used for washing boilers because the pressure was much higher than that of the private water supply.

Case 62. Water from a sprinkler system used to fill a cistern from which boiler feed was pumped at night.

Case 63. Switch engines filled with water from private fire protection hydrants.

Case 64. A manufacturing plant had a private 6-inch main to which fire hydrants were connected and from which four metered connections were run to the buildings where water was used for industrial purposes. The hydrants were installed for fire protection solely. The revenue from the four metered services was about $150 annually. The 6-inch main was metered and since then the revenue from this plant has exceeded $600 annually.

Case 65. A company which had been paying $300 annually for two unmetered fire protection lines paid $580 for the water used through these lines last year, as a result of installing meters on them.

Case 66. Surreptitious use of water by the engineer of a plant.

Case 67. Reports two cases, one of a plant where all the fixtures were supplied through a surreptitious connection.

Case 68. "We found a 2-inch line tapped into an 8-inch main in their yard and coming into a cellar under a concrete flooring, then rising up through a hollow brick wall and connecting to a steam pump which supplied the whole mill. In the cellar a 2-inch valve for a shut-off was located in a pit covered with a board and a thin covering of concrete laid on this board. A great many barrels were kept in this cellar and they made sure to keep a barrel covering the pit where the valve was."

Case 69. The engineer of a large industrial plant used water surreptitiously from a private fire service through a connection which was never discovered. This use was discovered by installing a metered by-pass at the valve on the private service, and the service was metered as soon as the use was proved.

Case 70. Metering a private service doubled the revenue from a main installed for both industrial use and fire protection, where only the connections for industrial use had been metered previously.

Case 71. Reports knowledge of many cases of surreptitious use, leading to metering the private fire protection services in the most flagrant cases.

Case 72. Reports knowledge of many cases of surreptitious use of water from unmetered fire protection services.

Case 73. Reports knowledge of a number of cases of surreptitious use, in one of which metering the fire protection service as well as the industrial connections showed that only 35 per cent of the water taken was being paid for.

Case 74. So many cases of surreptitious use of water were discovered that all private fire protection services are now metered.

Case 75. "Beg to advise that in two or three cases we have found illegal water connections made to private fire protection pipes. These connections were found something like ten years ago. In the last few years we have been making rigid inspections of all fire services and have not found any illegal connections, although we have found instances where the department seal had been removed from private fire hydrants without the knowledge of the department. In these cases we have assessed a penalty of from $5.00 to $10.00 for each seal ($5.00 for the first offense, $10.00 for the second)."

Case 76. Reports knowledge of a few cases of surreptitious use formerly, but all private services are now metered.

Case 77. Every unmetered private fire service was found to be supplying water without the knowledge of the department, so all such services are now metered.

Case 78. Reports recent discovery of a surreptitious 2-inch connection to an unmetered 6-inch fire line, made to furnish water to operate a curtain motor.

Case 79. Reports many cases of breakage of seals on the valves of private fire protection lines without the knowledge of the department.

Case 80. Every private fire service for industrial purposes was being used as a surreptitious source of supply, amounting in one case to about 500,000 gallons a day.

Case 81. Many cases of surreptitious use of water from unmetered fire protection services discovered, mainly made by employees without the knowledge of their responsible superiors.

Case 82. Reports numerous cases of small uses on unmetered connections. Many metered connections supposed to be used only for fire protection purposes show more or less steady consumption.

Case 83. Reports recovery of over $3500 for water stolen from a private fire protection service.

Case 84. Water from unmetered fire protection services was sold to ships.

Case 85. "One company of which I was superintendent had a 2-inch private fire protection service; after the same had been in use for about a year, the party asked to have it replaced by a 4-inch pipe, volunteering the information that he could not get water enough through the 2-inch. Attaching a meter to this service we found he was taking all the water the 2-inch pipe would deliver under 80-pounds pressure."

Case 86. Reports case of a break in a 6-inch subaqueous pipe on a private fire protection system which would have been discovered at once had the service been metered.

Case 87. Reports numerous connections by mechanics to unmetered fire protection system of a war industrial plant.

Case 88. See *Proc. A. W. W. A.*, 1903, p. 423.

Case 89. See *Proc. A. W. W. A.*, 1903, p. 429.

Case 90. See *Proc. A. W. W. A.*, 1903, p. 444.

Case 91. See *Proc. A. W. W. A.*, 1902, p. 67.

Case 92. See *Proc. A. W. W. A.*, 1907, p. 474.

Case 93. See *Proc. A. W. W. A.*, 1908, p. 10.

Case 94. See *Proc. A. W. W. A.*, 1908, p. 14.

Case 95. See *Proc. A. W. W A.*, 1908, p. 16.

Case 96. See *Proc. A. W. W. A.*, 1908, p. 17.

Case 97. See *Proc. A. W. W. A.*, 1908, p. 558.

Case 98. See *Proc. A. W. W. A.*, 1911, p. 14.

Case 99. See *Jour. N. E. W. W. A.*, 1897–1898, p. 96.

Case 100. See *Jour. N. E. W. W. A.*, 1900–1901, p. 423.

Case 101. See *Jour. S. E. W. W. A.*, 1900–1901, p. 427.

Case 102. See *Jour. N. E. W. W. A.*, 1902, p. 295.

Case 103. See *Jour. N. E. W. W. A.*, 1902, p. 296.

Case 104. See *Jour. N. E. W. W. A.*, 1903, p. 67.

Case 105. See *Jour. N. E. W. W. A.* 1903, p. 71.

Case 106. See *Jour. N. E. W. W. A.*, 1914, p. 65.

Case 107. Ten surreptitious connections made with high-pressure fire service system in New York, probably for filling roof tanks during the half-hour periods twice a day when the mains are filled for testing purposes using 200 pounds pressure. (*Proc. Nat. Fire Protection Assoc.*, 1915, p. 450.)

APPENDIX 2

Relating to "Bleeding" of Public Water Systems Due to Breakage of Private Fire Protection Services

Case 1. Jacksonville, Fla., see *Proc. A. W. W. A.*, 1902, p. 61.
Case 2. See *Proc. A. W. W. A.*, 1903, p. 365.
Case 3. Terre Haute, Ind., see *Proc. A. W. W. A.*, 1903, p. 422.
Case 4. Monroe, La., see *Proc. A. W. W. A.*, 1909, p. 618.
Case 5. Baltimore, Md., see *Proc. A. W. W. A.*, 1904, p. 456.
Case 6. Louisville, Ky., see *Proc. A. W. W. A.*, 1908, p. 555.
Case 7. New Orleans, La., see *Proc. A. W. W. A.*, 1908, p. 560.
Case 8. Spokane, Wash., see *Proc. A. W. W. A.*, 1912, p. 361.
Case 9. Jamestown, N. Y., see *Proc. A. W. W. A.*, 1912, p. 363.
Case 10. See *Proc. A. W. W. A.*, 1912, p. 378.
Case 11. Rockford, Ill., see *Proc. A. W. W. A.*, 1912, p. 380.
Case 12. St. Paul, Minn., see *Proc. A. W. W. A.*, 1913, p. 184.
Case 13. Milwaukee, Wis., see *Annual Report of Milwaukee Water Works*, 1912, p. 106.
Case 14. New Rochelle, N. Y., see *Jour. N. E. W. W. A.*, 1914, p. 60.
Case 15. Salem, Mass., see *Jour. N. E. W. W. A.*, 1915, p. 95.
Case 16. Pittsburgh, Pa., see *Jour. N. E. W. W. A.*, 1915, p. 100.
Case 17. Atlanta, Ga., see *Jour. N. E. W. W. A.*, 1915, p. 100.

APPENDIX 3

Relating to the Liability of a Water Utility for Fire Losses Occasioned by Failure of the Water Supply

The question of liability of the water utility for loss from fire due to its failure to provide an adequate water supply for the municipality and its inhabitants is one which has occasioned much discussion. It has, however, come to be almost universally held that in the absence of an express contract binding the utility to furnish an adequate supply under sufficient pressure for fire protection, there is no liability, either to a property owner or to the municipality in case of loss by fire occasioned by insufficiency of the supply. And even where an express contract is shown, it can only be taken advantage of by the parties to it. The weight of authority denies any liability in favor of the private property owner who seeks to recover under an express contract between the utility and the municipality, even though the contract specifically calls for sufficient water to afford adequate protection against fires. Most of the cases go on the principle that in contracting with the utility for a water supply the city is performing a governmental function, and for the performance or non-performance of such a function there can be no liablility.

In three states, however, a contrary rule is announced and adhered to. These minority cases are as follows: Muggs vs. Tampa Waterworks Co., 42 So. 81, 52 Fla. 371; Gorrell vs. Greenboro Water Supply Company, 124 N. C. 328, 325 S. E. 720; Fisher vs. Greenboro Water Supply Company, 128 N. C.

375, 38 S. E. 912; Guardian Trust Co. vs. Greensboro W. Supply Co., 115 Fed. 184; Guardian Trust Co. vs. Fisher, 200 U. S. 57; Graves County Water Company vs. Ligon, 112 Ky. 775, 66 S. W. 726; Georgetown, etc. Co. vs. Neale, 137 Ky. 197, and Kenton, W. Co. vs. Glenn, 141 Ky. 529.

This doctrine has been applied, apparently, in only three jurisdictions, namely, Florida, North Carolina and Kentucky. In all other states the courts have uniformly refused to hold the utility liable, under its contract with the municipality, for losses sustained by property owners on account of failure to provide water in sufficient amount and at sufficient pressure to comply with the franchise. These decisions are so numerous that it would be wholly impracticable to reproduce all of them here. A few representative decisions have been selected as illustrative of the majority rule. They are divided into two heads, losses of private owners and losses of municipalities.

Losses of private owners. German Alliance Ins. Co. vs. Home Water Co., 226 U. S. 220; Baum vs. Somerville Water Co. (N. J.), 87 Atl. 140; and Krom vs. Antigo Water Co., 154 Wis. 528.

Losses of municipalities. The liability for loss of city property due to failure of the water supply has been touched upon in but few cases. Such as there are seem to indicate the following general principles:

The liability must depend very largely upon the nature of and construction of the contract between the utility and the municipality.

Where the undertaking of the company is merely to establish a plant and supply water, without any stipulation to afford protection from fire, no liability for fire losses sustained by the municipality will attach.

It is always open to the parties to expressly enter into contracts whereby water companies may be held liable for damages resulting to municipal property by fire because of the failure of the water company to furnish a sufficient supply, and where such a contract exists and it is clear that the lack of water caused the loss, there can be no doubt of the municipalities' right to recover.

This was recognized in Milford vs. Bangor R. & E. Co., 104 Me. 233, 71 Atl. 759. A very similar contract was considered in Ukiah City vs. Ukiah Water and Impr. Co., 142 Cal. 173, 64 L. R. A. 231, and it was held that where such a contract is entered and there is no provision for the protection of specific property, the municipality is in the same position as a private individual and cannot recover. But it is said:

"Doubtless a water company may so bind itself by contract with a person to furnish him water for the extinguishment of fires, as to render itself liable for the value of property of such person destroyed by fire by reason of its failure to furnish him with a sufficient supply of water, and it may be assumed that it is within the power of a municipality, as a property owner, to enter into such a contract with the Water Company for the protection of the property which it owns as a legal individual; but it certainly needs more than evidence showing an accepted service for general fire purposes to establish such a contract."

In Galena vs. Galena Water Co., 132 Ill. App. 332, affirmed in 229 Ill. 128, 82 N. E. 421, the court said: "If, as alleged in the declaration, the water company failed to perform these provisions of the contract, and if that failure caused a loss by fire to property owned by the city, we see no good reason why

the water company should not be responsible to the city for the proximate results of such breach of contract."

In Houck vs. Cape Giradeau Water Works & Electric Light Company, 114 S. W. (Mo.) 1099, an ordinance was involved which granted the right to furnish water to the city and its inhabitants at a pressure adequate for fire protection without the use of fire engines. It was held that the palpable meaning of the contract was that sufficient pressure should be maintained to afford reasonable protection to all buildings, whether owned by the city itself or its inhabitants, and therefore the company was liable for the loss.

Among the great number of cases illustrating the general rule of nonliability to individual property owners may be noted the following:

Fowler v. Athens City W. W. Co. 83 Ga. 219, where it is held that the private citizen not only has no right of action *ex contractu* but has none *ex delicto* since the water company's breach of contract with the municipality was a mere omission or nonfeasance, which is not a tort, direct or indirect, to the private property of the individual.

Becker v. Keokuk W. W. 79 Iowa, 419; Mott v. Cherryvale W. Co. 48 Kan. 12; Howsman v. Trenton W. Co. 119 Mo. 304; Wainwright v. Queens Co. Water Co. 78 Hun. (N. Y.) 146; Butterworth v. Henrietta, 25 Tex. Civ. App. 467; Michol v. Huntington W. Co. 53 W. Va. 345, holding that the fact a supply of water is paid for by taxes levied by the city does not entitle a taxpayer whose property is injured, or destroyed to maintain an action against the water company.

Van Horn v. Des Moines, 63 Iowa 447; Smith v. Great South Bay W. Co. 82 App. Div. (N. Y.) 427, holding that a contract between the city and the utility whereby the latter agrees to pay all damages that may accrue to any citizen by reason of failure of the utility to furnish sufficient water to extinguish fires does not entitle a citizen who sustains a fire loss to maintain an action against the water company. Such a contract is beyond the power of the city, unless specifically authorized by statute. See also Becker v. Keokuk W. W., Mott v. Cherryvale W. Co. and Howsman v. Trenton W. Co. above cited, and Boston Safe Dep. Co. v. Salem W. Co. 94 Fed. 238.

Nor has an insurance company which has paid a loss on the property any greater rights than had the insured; Phoenix Ins. Co. v. Trenton W. Co., 42 Mo. App. 119.

And where the water company contracted with the city to furnish a water supply adequate for fire protection, it was not entitled to sue for a loss sustained by one of its citizens, since the city had not the requisite interest in property; Ferris v. Carson W. Co. 16 Nev. 44. So in an action by the water company against the city, the latter will not be permitted to counterclaim damages for fire losses sustained by its citizens by reason of the insufficiency of the supply; Montgomery v. Montgomery W. W. 79 Ala. 233.

And even in Kentucky, where, as has been seen, recovery is allowed as for a tort, the utility was held not liable for a failure of the supply due to an accident which by the exercise of ordinary care could not have been provided against or even anticipated; Springfield F. & M. Ins. Co. v. Graves Co. W. Co. 85 S. W. 205.

The foregoing may suffice to show the universal application of the rule denying liability as between the property owner and the company under contracts between the utility and the municipality, but additional authority is found in the decisions listed below:

Alabama. Lovejoy v. Bessemer W. W. Co., 146 Ala. 374, 41 So. 76, 6 L. R. A. (NS) 429. Ellis V. Birmingham W. Co., 65 So. (Ala.) 805.

Arkansas. Collier v. Newport W. L. & P. Co., 100 Ark. 47; 139 S. W. 635.

Connecticut. Nickerson v. Bridgeport Hydraulic Co., 46 Conn. 24.

Georgia. Fowler v. Athens City W. W. Co., 83 Ga. 219, 9 S. E. 673. Holloway v. Macon & Co., 132 Ga. 387, 64 S. E. 330.

Idaho. Bush v. Artesian H. & C. W. Co., 4 Idaho 618, 43 Pac. 69.

Illinois. Peck v. Sterling W. Co., 118 Ill. App. 533. Rostad v. Suburban W. & L. Co., 163 Ill. App. 63.

Indiana. Fitch v. Seymour W. Co., 139 Ind. 214, 37 N. E. 982.

Iowa. Davis v. Clinton W. W. Co., 54 Ia. 59, 6 N. W. 126.

Louisiana. Allen Mfg. Co. v. Shreveport W. W. Co., 113 La. 1091; 37 So. 980.

Massachusetts. Hand v. Brookline, 126 Mass. 324.

Mississippi. Wilkinson v. L. H. & W. Co., 78 Miss. 389, 28 So. 877.

Missouri. Metz v. Cape Girardeau W. Co., 202 Mo. 324, 100 S. W. 651.

Nebraska. Eaton v. Fairbury W. Co., 37 Neb. 546, 56 N. W. 201, 21 L. R. A. 650.

New Jersey. Knappman Whiting Co. v. Middlesex W. Co., 64 N. J. L. 240, 45 Atl. 692, 49 L. R. A. 572.

Ohio. Blunk v. Dennison W. S. Co., 71 Oh. St. 250. Akron W. W. Co. v. Brownlesa, 10 Oh. CC. 620.

Oklahoma. Lutz v. Tahlequah W. Co., 29 Okla. 171, 118 Pac. 128, 36 L. R. A. (NS) 568.

Pennsylvania. Thompson v. Springfield W. Co., 215 Pa. St. 275.

South Carolina. Ancrum v. Camden W. Co., 82 S. C. 284, 64 S. E. 151, 21 L. R. A. (NS) 1029. Cooke v. Paris Mt. W. Co., 82 S. C. 235, 64 S. E. 157.

Tennessee. Foster v. Lookout W. Co., 3 Lea, 42; Harris v. Columbia W. & L. Co., 114 Tenn. 328, 85 S. W. 897.

Texas. House v. Houston W. Co., 88 Tex. 233., 31 S. W. 179. Greenville W. Co. v. Beckham, 118 S. W. 889. Josey v. Beaumont W. Co., 183 S. W. 26.

Vermont. Wilkins v. Rutland, 61 Vt. 336.

We have thus far touched only in an incidental way the question of liability in the case of a water company under contract direct with the consumer to furnish him fire protection. It is found, however, that not every contract between a utility and a consumer will sustain an action for damages sustained by reason of insufficient provision for fire protection. And it will be noted that in this respect there is no difference between a private corporation furnishing water and a municipality as a water utility. Neither is liable to the property owner unless there has been an express engagement to supply water for fire protection purposes. The ground is sometimes taken that unless the water company has contracted to furnish sufficient water for fire protection, the resulting loss cannot be said to have been within the contemplation of the parties when the contract was made, and therefore damages are not recover-

able. In many of the cases where liability was denied as to a municipality, the theory has been adopted that the city has a discretionary power, under its charter, to provide fire protection if it sees fit to do so, and the power being discretionary and governmental, the city will not be liable for mere neglect to exercise it. It is pointed out that the contrary rule would make the city an insurer of all property against fire, and sound public policy forbids the imposition of such a duty.

Municipal water utilities. Among the decisions which deny liability in the municipality are the following: Van Horn v. Des Moines, 63 Ia. 447; Wheeler v. Cincinnati, 19 Oh. St. 19; Heller v. Sedalia, 53 Mo. 159; Brinkmeyer v. Evansville, 29 Ind. 187; Tainter v. Wooster, 123 Mass. 311; Grant v. Erie, 69 Pa. 420; Black v. Columbia, 19 S. C. 412; Mendel v. Wheeling, 28 W. Va. 253; Springfield F. & M. Ins. Co. v. Keeseville, 148 N. Y. 46; Wright v. Augusta, 78, 241; Planters Oil Mill v. Monroe W. & L. Co. 52 La. 1243, 27 So. 684; Miller v. Minneapolis, 75 Minn. 131, 77 N. W. 788.

But a municipality may legally contract, for hire, to furnish a person with water for any lawful purpose, and if it does so it will be liable, as a private corporation is liable, for any damage proximately resulting from a breach of its agreement. Watson v. Needham, 161 Mass., 404, 37 N. E. 204; Stock v. Boston, 149 Mass. 410, 21 N. E. 871; Lenzen v. New Braunfels, 13 Tex. C. A. 335, 35 S. W. 341.

Private water companies; special contracts. As above suggested, the cases show that the liability of the water company under contract with the consumer must depend on the terms of the contract, and no liability for losses by fire can be predicated upon a general engagement to supply the consumer with water. The non liability, in other words, depends, not on the inability of the consumer to maintain the action, but upon the failure of the contract to cover such a liability. See Middlesex W. Co., 64 N. J. L. 240, 45 Atl. 692; Muscatine W. Co. v. Muscatine Lbr. Co., 85 Iowa 112; 52 N. W. 108; New Orleans & N. E. Ry. Co. v. Meridian W. W. Co., 72 Fed. 227; Lottman v. Houston W. W. Co. (Tex.), 38 S. W. 357; Harris & Coale Bros. v. Columbia W. & L. Co., 114 Tenn. 328, 85 S. W. 897; Nichol v. Huntington W. Co., 53 W. Va. 348, 44 S. E. 290; Hunt Bros. Co. v. San Lorenzo W. Co., 150 Cal. 51, 87 Pac. 1093; Neiheus Bros. Co. v. Contra Costa W. Co., 159 Cal. 305; 113 Pac. 375; Jones House Furn. Co. v. Arkansas W. Co., (Ark.) 166 S. W. 557, 52 L. R. A. (NS) 402; Hall v. Passaic W. Co., 83 N. J. L. 771, 85 Atl. 349; Baum v. Somerville W. Co., 84 N. J. L. 611, 87 Atl. 140; Dublin El. & G. Co. v. Thompson (Tex.), 166 S. W. 113; Bessemer W. Co. v. Murphy, 6 Ala. App. 603, 60 So. 533; Peoples Nat. Bank v. Kennebec W. Dist., 107 Me. 542, 81 Atl. 866; and Warren Co. v. Hanson (Ariz.), 150 Pac. 238.

APPENDIX 4

Relating to Pollution of Public Water Supplies from Independent Fire Service Supplies through Private Fire Service Connections

Case 1. Milwaukee, Wis., 1912. "In connection with the inspection of the fire sprinkling system, it was discovered that in several plants the back

pressure from the fire pumps drawing water from the river as a secondary source of supply was polluting our domestic supply owing to defective check valves. This was proven by pressure tests made and also by having an analysis made of the water drawn from the nearest hydrant. These fire pumps pump from the river, which is often highly polluted. In order to guard against this dangerous procedure, defective check valves were ordered repaired, and in order to further safeguard our domestic supply the discharge valves of the fire pumps were ordered closed and sealed by the department. This removes all danger of pollution unless the check valve should be found defective in case of fire." (*Milwaukee Water Works Annual Report*, 1912, page 21).

Case 2. Philadelphia, Pa., 1913. "The Bureau of Health of Philadelphia investigated a typhoid epidemic which it was found came from the pollution of the city main by what are called "dual water systems." Check valves were found to be in the piping system, but in many cases failed to operate properly. The city had 77 such connections. Absolute separation of all such systems was required and no future installation of this type of connection was permitted. The result was that the contamination disappeared." (Letter from Stamford Water Company, Stamford, Conn.)

Case 3. Van Wert, Ohio. "About 300 cases typhoid fever, 5 deaths, Cincinnati Northern Railway Company direct connection cut off. Supply from city now discharges into elevated tank in such a manner as to make it impossible to drain into city mains." (Letter from Stamford Water Company, Stamford, Conn.)

Case 4. Circleville, Ohio. "Forty-three cases of typhoid, and 3 deaths, American Straw Board connection. They had two gates and *two check valves*, gates were left open and checks leaked. After gates were closed the epidemic stopped." (Letter from Stamford Water Company, Stamford, Conn.)

Case 5. New Bedford, Mass., 1903 "A fire occurred at one of the large mills. The salt water pumped by the mills passed through leaking check valves to the city main in such large amounts as to entirely disable the city department steamers." (Letter from Stamford Water Company, Stamford, Conn.)

Case 6. Springfield, Ohio, 1911. "Small outbreak of typhoid fever. Many cases were found among employees of the International Harvester Company. The conclusion was that water got back from the fire lines of the factory through a leaking check valve and was then fed into the factory from the city mains, which supply was used for drinking purposes. A similar case was observed in Tontrante, Ontario, when check valve failed to work." (Letter from Stamford Water Company, Stamford, Conn.)

Case 7. Elgin, Ill., 1916. "One of the most recent epidemics attributed to this cause (dual private fire systems) occurred September, 1916, where the employees of a large watch factory suffered severely. This disastrous outbreak has had an especially instructive sequel since under the Illinois Compensation Act the death claims—eighteen in number—against the watch company have been settled through the agency of the State Industrial Board. The action of the manufacturing corporation seems to have been exemplary since the very onset of the epidemic; not only have the death settlements

been adjudicated with the complete cooperation of the factory officials, but also during the progress of the epidemic the medical and hospital responsibility and expenses were promptly assumed by the watch company. It is estimated that the actual outlay by the manufacturer in behalf of the typhoid sufferers will be approximately $100,000." *Journal Am. Med. Assoc.*, February 10, 1917, p. 465.

Case 8. Utica, N. Y., 1917. "A rather serious outbreak of typhoid fever in the City of Utica was clearly traced to infection arising out of one of these auxiliary supplies in one of the many mills in the City. It was rather a coincidence that at about this time another smaller outbreak occurred in a mill in the City of Rensselaer, N. Y., arising out of the same cause. As a result of these epidemics and the causes for them, this Department took very definite action in the particular case of the City of Utica and followed this subsequently by general action toward all of the municipalities in the State.

"In the particular case of Utica, following the epidemic, and incorporated in our report thereon, we recommended a complete severance of the auxiliary fire supplies in the case of all the mills in the City, a dozen or more as I recall. We immediately ran into a very determined opposition from not only the mill owners in Utica but from the Underwriters companies in and outside of the State of New York, many of which as might be expected, were doing business in the State. . . . .

"I had very clearly made up my mind that I had to discriminate sharply between the theoretical or altruistic viewpoint and the more practical and economical one. Convinced as I was that the only absolutely safe course would be an absolute severance of such supplies, a viewpoint which I think would be assumed by most of us, I felt that from the more practical standpoint this course would be a somewhat drastic and severe one, particularly at the present time, or until the subject could be more definitely aired as to all its merits and a more general concensus of opinion obtained among engineers and sanitarians. . . . .

"What was particularly important in my mind was the fact that, after a careful investigation I could not find any authentic case where a double check valve was properly installed, which resulted in an outbreak of typhoid fever. There may have been some but I do not know of them. Where single check valves have been installed I think there are some cases recorded where epidemics have resulted. . . . .

"The question then simmered down to a decision as between 'absolute severance' and the installation of the double check valve, properly installed, readily accessible, easily tested and subject to as good supervision as could be maintained locally. . . . .

"My final personal feeling is that the double check valve, properly installed and supervised, is so vast an improvement over the past 'hit or miss' conditions of installation in many if not most of our factories, that we would be making a sufficient step in advance at this time if we advance over the old system and adopt the double check valve system with the restrictions as we have imposed." (Letter from New York State Department of Health.)

Case 9. St. Catharines, Ontario, Canada; see *Proc. A. W. W. A.*, 1910, p. 228.

Case 10. Hartford, Conn.; see *Proc. A. W. W. A.*, 1910, p. 230.

Case 11. Lowell, Mass., 1903; see *Proc. A. W. W. A.*, 1910, p. 231.

Case 12. Rockford, Ill., 1912; see *Proc. A. W. W. A.*, 1912, p. 380.

Case 13. Toronto, Canada; see *Proc. A. W. W. A.*, 1913, p. 163–164.

Case 14. See *Proc. A. W. W. A.*, 1913, p. 164.

Case 15. New Bedford, Mass.; see *Jour. N. E. W. W. A.*, 1903, p. 69.

Case 16. Nashua, N. H.; see *Jour. N. E. W. W. A.*, 1910, p. 382–383.

Case 17. See *Jour. N. E. W. W. A.*, 1910, p. 383.

Case 18. Lawrence, Mass.; see *Jour. N. E. W. W. A.*, 1910, p. 403.

Case 19. Auburn, N. Y.; see *Jour. N. E. W. W. A.*, 1910, pp. 407 and 410.

Case 20. St. Paul, Minn. "On October 24, 1914, an outbreak of dysentery among the employees of the St. Paul Union Stock Yards Company at South St. Paul, Minn., was reported by the Live Stock Exchange Company to the Minnesota State Board of Health. Investigation showed that about 80 of these employees developed symptoms of dysentery between October 21 and 24, the majority of them on the night of October 21. It also brought out the fact that all these persons were using water from the distribution system of the St. Paul Union Stock Yards Company. The regular water supply of this company was pumped from three drilled wells located at the yards, but on certain days of each week, when shipments of live stock were heavy, the supply was augmented by water obtained through a connection with the mains of the buildings of the Swift & Company packing plant, known as the distillery building. The water supplied to this building was pumped from a drilled well. For fire protection there exists a system of mains supplied with water pumped from the Mississippi River through an intake. This fire protection system was connected with both the Union Stock Yards distribution system and the distillery building system. . . . .

"It was discovered during the investigation that Swift & Company had furnished water to the Union Stock Yards system on October 19 and 20, at which time Mississippi River water doubtless had entered the Union Stock Yards system.

"During the investigation analytical control was maintained on the water supplies involved. Contamination was found present in the distribution system of the Union Stock Yards Company, but was not found in the water in the various drilled wells connected with the supply. These results corroborate the information just given concerning the source of the pollution of the supply. The distribution system of the Union Stock Yards Company was disinfected with calcium hypochlorite and the contamination removed." (Letter from Minnesota State Board of Health.)

Case 21. Mannington, W. Va. "Three years ago a slight amount of typhoid was experienced at Mannington that may possibly have been attributable to the water from the South Penn Oil Company's system being under higher pressure, leaking around the valve and entering the municipal supply. The connection was provided, not alone for the protection of the South Penn Oil Company, but to furnish the city with water in case of conflagration and any emergency at their plant." (Letter from West Virginia Department of Health.)

Case 22. Nitro, W. Va. "Several thousand cases of so-called dysentery were quite largely due to the connection between the fire service and the

drinking water supply. A certain amount of water was filtered and heavily chlorinated and pumped into the drinking water mains. The fire service was supplied with raw unfiltered water taken directly from the river. There are several cross connections between the two services and some of these were open and it was quite possible for the water from the fire service to pass into the drinking water mains. It was maintained by those in charge that the filtered water was heavily enough chlorinated to take care of the unchlorinated raw river water. The river receives all the sewage of Charleston, South Charleston, Dunbar and St. Albans, all good sized communities and consequently was highly polluted." (Letter from West Virginia Department of Health.)

Case 23. Piedmont, W. Va. "An epidemic of some 470 cases of typhoid in a population of less than six thousand, was due to the use of a fire service connection from a polluted source of supply." (Letter from West Virginia Department of Health.)

Case 24. Massachusetts. "In a case where a fire supply was taken from a fairly clean river a serious epidemic of typhoid occurred which, it was learned afterward, began within about two weeks after the test of the fire pumps had been made at the mill. The further investigation also disclosed that a new sewer outlet had been constructed into the river a short distance above the fire supply intake shortly before the date of the test. In the case of another mill village a typhoid epidemic developing soon after a fire in the mills was traced to a similar cause, viz., a new sewer outlet constructed into a river not ordinarily polluted a short distance above the fire supply intake. The construction of new sewer outlets into rivers is subject to approval by the State Department of Health, but in the small villages such outlets are sometimes built without notifying the State Department of Health.

"Two other cases present serious suspicions. The typhoid rates in these two cities were high and the cause was not ascertained. An examination of certain check valves, however, showed that they were in exceedingly bad condition and probably inoperative. After they were removed and the fire supply, which in each case was taken from a polluted river, was separated from the public supply the typhoid rate decreased to normal." (Letter from Massachusetts State Department of Health.)

To the above instances of pollution could be added a number of cases in other towns, such as Watervliet, Newburg, Herkimer, Saugerties, and Hoosick Falls, N. Y., and Akron, Ohio.

APPENDIX 5

Relating to the Question of Whether the Utility or the Customers Should Bear the Expense of Installing and Maintaining Service Connections and Meters

Service Connections

Cost of connections

a. View that utility must bear expense. It is held by the courts in the following cases that a water utility is bound to install at its own expense service

connections between the main and the curb, upon the ground that such connections form a part of the distribution system: Title Guarantee & T. Co. v. Railroad Commission, 168 Cal. 295, 142 Pac. 878, Ann. Cas. 1916A, 738; Pocatello Water Co. v. Standley, 7 Idaho, 155, 61 Pac. 518; Bothwell v. Consumer's Co. 13 Idaho, 568, 24 L. R. A. (N. S.) 485, 92 Pac. 533; Hatch v. Consumer's Co. 17 Idaho, 204, 40 L. R. A. (N. S.) 263, 104 Pac. 670, affirmed in 224 U. S. 148, 56 L. ed. 703, 32 Sup. Ct. Rep. 465; Bartlesville Water Co. v. Bartlesville, 150 Pac. 118; International Water Co. v. El Paso, 51 Tex. Civ. App. 321, 112 S. W. 816.

This rule has been applied by the Commissions in the following cases:

Re Hawthorne Electric & Water Co. 1 Cal. R. C. R. 972; Glendale v. Title Guarantee & T. Co. 2 Cal. R. C. R. 989; Re San Gorgonio Water Co. 2 Cal. R. C. R. 706; Re Lawndale Land & Water Co. 2 Cal. R. C. R. 886; Re Murray, 2 Cal. R. C. R. 521; Dooley v. People's Water Co. (1913) 3 Cal. R. C. R. 953; Re Covina City Water Co. 3 Cal. R. C. R. 1212; Pasadena Consol. Water Co. (1914) 5 Cal. R. C. R. 180; Re Water, Gas, Electric & Teleph. Utilities, 7 Cal. R. C. R. 830, P. U. R. 1915E, 741; Re Cripple Creek Water Co. (Colo.) P. U. R. 1916C, 788; Re Village Council (Idaho) Case No. 184, Order No. 357, June 9, 1916; Commercial Club v. Terre Haute Waterworks Co. (Ind.) P. U. R. 1916B, 180; Re Redkey (Ind.) No. 1937, July 18, 1916; Public Service Commission v. Water Utilities (Mont.) P. U. R. 1915E, 866; Lane v. Tuckerton Water Co. (N. J.) June 15, 1915, cited in P. U. R. 1916B, 22; South Buckhannon v. Buckhannon Light & Water Co. (W. Va.) P. U. R. 1915F, 383; Janesville v. Janesville Water Co. 7 Wis. R. C. R. 628.

b. View that consumer may be required to bear expense. The following cases hold that a water utility may require consumers to pay for service connections between the main and the curb; Prindiville v. Jackson, 79 Ill. 337; Warren v. Chicago, 118 Ill. 329, 9 N. E. 883, 11 N. E. 218; Fisher v. St. Joseph Water Co. 151 Mo. App. 530, 132 S. W. 288; Joplin v. Wheeler, 173 Mo. App. 590, 158 S. W. 924; Wichita v. Wichita Water Co. 138 C. C. A. 337, 222 Fed. 789; Public Service Commission v. Water Utilities (Mont.) P. U. R. 1915E, 866.

Duty to repair

a. View that utility must repair. There is a conflict among the cases passing upon the duty to repair the service connections.

It has been held that a water utility must keep in repair the service connections located in the street, notwithstanding they were owned or paid for by the abutting property owners. Van Norman v. Meridian Waterworks Co. 102 Miss. 736, 43 L. R. A. (N. S.) 144, 59 So. 883; Brown v. Meridian, 102 Miss. 384, 59 So. 795; Gilmore v. Hackensack Water Co. (N. J.) P. U. R. 1916B, 21; Re Columbus Water & Light Comr's., 11 Wis. R. C. R. 449; Re Delevan, 12 Wis. R. C. R. 148; Colne Valley Water Co. v. Hall, 96 L. T. N. S. 395, 71 J. P. 173, 5 L. G. R. 260; Chapman v. Fylde Waterworks Co. (1894) 2 Q. B. 599, 64 L. J. Q. B. N. S. 15, 9 Reports, 582, 71 L. T. N. S. 539, 43 Week Rep. 1, 59 J. P. 5.

b. View that consumer must repair. See McClaugherty v. Bluefield Waterworks & Improv. Co. 67 W. Va. 288, 32 L. R. A. (N. S.) 229, 68 S. E. 28;

Jackson v. Ellendale, 4 N. D. 478, 61 N. W. 1030; Fisher v. St. Joseph Water Co. 151 Mo. App. 530, 132 S. W. 288; Sheffield Waterworks Co. v. Wilkinson, L. R. 4 C. P. Div. 410, at page 421, 48 L. J. Mag. Cas. N. S. 145; Grand Junction Waterworks Co. v. Rodocanachi (1904) 2 K. B. 230, at page 237, 73 L. J. K. B. N. S. 441, 68 J. P. 290, 52 Week. Rep. 508, 90 L. T. N. S. 819, 20 Times L. R. 410, 2 L. G. R. 689; Batt v. Metropolitan Water Board (1911) 2 K. B. 965, 80 L. J. K. B. N. S. 1354, 105 L. T. N. S. 496, 75 J. P. 545, 27 Times L. R. 579, 55 Sol. Jo. 714; 9 L. G. R. 1123 reversing (1911) 1 K. B. 850, 80 L. J. K. B. N. S. 521, 104 L. T. N. S. 385, 75 J. P. 174, 27 Times L. R. 258, 55 Sol. Jo. 330, 9 L. G. R. 307; Chapman v. Fylde Waterworks Co. (1894) 2 Q. B. 599, 64 L. J. Q. B. N. S. 15, 9 Reports, 582, 71 L. T. N. S. 539, 43 Week. Rep. 1, 59 J. P. 5, was excluded. Ibid.

Expense of enlarging service connections. It is the duty of a water utility to enlarge the connections between the main and the curb at its own expense, where they do not furnish a sufficient supply of water; but where the service connections are sufficient, and the fault is with the pipes of the consumer, the company is not obliged to furnish an additional connection free of charge. South Buckhannon v. Buckhannon Light & Water Co. (W. Va.) P. U. R. 1915F, 383.

Meters

Ownership and maintenance. In general.

The Commissions have held in numerous cases that it is the duty of a public utility to install and maintain meters at its own expense upon the ground that the meter is a part of the plant or system which the utility should own. Re Hawthorne Electric & Water Co. 1 Cal. R. C. R. 972; Re San Gorgonio Water Co. 2 Cal. R. C. R. 706; Re Lawndale Land & Water Co. 2 Cal. R. C. R. 886; Glendale v. Title Guarantee & T. Co. 2 Cal. R. C. R. 989; Re Jackson, 3 Cal. R. C. R. 185; Tujunga Valley Improv. Asso. v. Tujunga Water & P. Co. 3 Cal. R. C. R. 774; Dooley v. People's Water Co. 3 Cal. R. C. R. 948, 26 C. L. 1142; Eagle Rock v. Eagle Rock Water Co. 3 Cal. R. C. R. 1054; Re Covina City Water Co. 3 Cal. R. C. R. 1212, 27 C. L. 276; Re Pasadena Consol. Water Co. 5 Cal. R. C. R. 180; Belvedere Civic Asso. v. Janss Co. 5 Cal. R. C. R. 415; Nouguier v. Van Nuys (1914) 5 Cal. R. C. R. 851; Re San Jose Water Co. (Cal.) P. U. R. 1915E, 706; East Bakersfield Improv. Asso. v. San Joaquin Light & P. Corp. (Cal.) P. U. R. 1916C, 830; Re Murray (Idaho) 30 C. L. 1347; Re Pinckneyville Light, Ice, & P. Co. 1 Ill. P. U. C. R. 675; Currant v. Homer Electric Light & P. Co. (Ill.) P. U. R. 1916A, 917; Woll. v. Hullinger (Ill.) P. U. R. 1916D, 380; Apple v. Brazil (Ind.) P. U. R. 1915C, 561; Cole v. Ft. Scott & N. Light, Heat, Water & P. Co. (Mo.) 26 C. L. 1191; Brown v. Lawrence County Water, Light & Coal Storage Co. 1 Mo. P. S. C. R. 355; Weaver v. Kirksville Light Power & Ice Co. 1 Mo. P. S. C. R. 564; Public Service Commission v. Water Utilities (Mont.) P. U. R. 1915E, 866.

But in Leavenworth v. Leavenworth City & Ft. L. Water Co. P. U. R. 1915B, 611, the Kansas Commission held that a rule requiring patrons to purchase their water meters from the company is reasonable, provided the com-

pany buys them to the best advantage and sells them without profit, and the meters are such as give the best service at the least expense. It has been held that a municipal ordinance requiring a utility to install and maintain meters without charge to consumers is reasonable. Spring Valley Waterworks v. San Francisco, 82 Cal. 286, 6 L. R. A. 756, 16 Am. St. Rep. 116, 22 Pac. 910, 1046; Title Guarantee & T. Co. v. Railroad Commission, 168 Cal. 295, 142 Pac. 878, Ann. Cas. 1916A, 738; Toledo R. & Light Co. v. Toledo (Ohio Commission) 19 C. L. 289.

On the other hand, some courts have held that an ordinance of a city operating a waterworks requiring consumers to bear the expense of meters is reasonable. Farkas v. Albany, 141 Ga. 833, L. R. A. 1915A, 320, 82 S. E. 144, Ann. Cas. 1915C, 1195; Cooper v. Goodland, 80 Kan. 121, 23 L. R. A. (N. S.) 410, 102 Pac. 244; Powell v. Duluth, 91 Minn. 53, 97, N. W. 450; State ex. Rel. Hallauer v. Gosnell, 116 Wis. 606, 61 L. R. A. 33, 93 N. W. 542; Swanberg v. New York, 123 App. Div. 774, 108 N. Y. Supp. 364; Shaw Stocking Co. v. Lowell, 199 Mass. 118, 18 L. R. A. (N. S.) 746, 85 N. E. 90, 15 Ann. Cas. 377; State ex rel. Hallauer v. Gosnell, 116 Wis. 606, 61 L. R. A. 33, 93 N. W. 542.

Under the decisions of the courts the right of a municipality operating a public utility to require the use of meters at the expense of the consumers seems to depend upon its statutory or charter powers. Montgomery v. McDade, 180 Ala. 156, 60 So. 797; Montgomery v. Greene, 180 Ala. 322, 60 So. 900; Albert v. Davis, 49 Neb. 579, 68 N. W. 945; State ex rel. Hallauer v. Gosnell, 116 Wis. 606, 61 L. R. A. 33, 93 N. W. 542; Cooper v. Goodland, 80 Kan. 121, 23 L. R. A. (N. S.) 410, 102 Pac. 244; Farkas v. Albany, 141 Ga. 833, L. R. A. 1915A, 320, 82 S. E. 144, Ann. Cas. 1915C, 1195; Mallon v. Water Comrs. 144 Mo. App. 104, 128 S. W. 764; Sackett v. Morris, 149 Ill. App. 152; Farkas v. Albany, 141 Ga. 833, L. R. A. 1915A, 320, 82 S. E. 144, Ann. Cas. 1915C, 1195; Wilson Water & Electric Co. v. Arkadelphia, 95 Ark. 605, 129 S. W. 1091; Spencer v. Missouri Public Utilities Co. 1 Mo. P. S. C. R. 664; Bellis v. Cushing Gas Co. (Okla.) 24 C. L. 672; and Jackman v. Verdi Lumber Co. (Nev.) U.-86, May 24, 1916.

Grounds for relieving utility of necessity of furnishing meters. In jurisdictions in which it is the declared policy that the utility must furnish meters at its own expense, certain utilities have been relieved from the necessity of furnishing meters on account of financial and other considerations. See in Re Shelbyville Gas Co. No. 5292, July 27, 1916, Illinois Commission; Washburn v. Washburn Waterworks, 6 Wis. R. C. R. 74; in Re Hudson Waterworks, 3 Wis. R. C. R. 138; Alter v. Manitowoc, 14 Wis. R. C. R. 690; in Re Delavan, 12 Wis. R. C. R. 148; in Re Durand Municipal Waterworks Plant, 11 Wis. R. C. R. 169; Re Oconto City Water Supply Co. 7 Wis. R. C. R. 497; Re Cashton Municipal Light & Water Commission, 11 Wis. R. C. R. 410; Re Ashland Water Co., 14 Wis. R. C. R. 1; Re Gilmanton Mill & Electric Plant, 14 Wis. R. C. R. 152; Re Fennimore (Wis.) P. U. R. 1916A, 848; Re Platteville Municipal Waterworks (Wis.) P. U. R. 1915E, 705.

Acquisition of consumers' meters. See Re Municipal Waterworks & Electric Lighting Plant, 15 Wis. R. C. R. 534; Re Ft. Atkinson Water & Light Commission, 12 Wis. R. C. R. 260; Re Burlington Electric Light & P. Co. (Wis.) P. U. R. 1915B, 117; Public Service Commission v. Water Utilities (Mont.)

P. U. R. 1915E, 866; Wall v. Hullinger (Ill.) P. U. R. 1916D, 380; Current v. Homer Electric Light & P. Co. (Ill.) P. U. R. 1916A, 917.

Maintenance of meters. It has been held that the maintenance of meters, whether owned by the utility or by the consumer, is an expense to be borne by the utility as a proper charge to operating expenses. Janesville v. Janesville Water Co. 7 Wis. R. C. R. 628; Dennett v. Sheboygan, 14 Wis. R. C. R. 634; Re Delavan, 12 Wis. R. C. R. 148; Commercial Club v. Terre Haute Waterworks Co. (Ind.) P. U. R. 1916B, 180; Roundup v. Roundup Coal Min. Co. P. U. R. 1916D, 393.

APPENDIX 6

Relating to Decisions of Courts and Public Utility Commissions with Respect to Charges for Public and Private Fire Protection Service

Commission Decisions. Twenty-two of the 48 states do not have state commissions vested with jurisdiction over water utilities. These are: Vermont, New York, Maryland, South Carolina, Georgia, Florida, Louisiana, Michigan, Minnesota, South Dakota, Iowa, Nebraska, Arkansas, Oklahoma, Texas, New Mexico, Kentucky, Tennessee, Mississippi, Utah, Wyoming, and Delaware.

In only 8 of the other 26 states have any rules or decisions affecting private fire protection service been laid down by public utility commissions vested with jurisdiction over water companies. These states are: Wisconsin, Oregon, Maine, Indiana, Illinois, New Jersey, California, and Pennsylvania.

The Public Utility Commission of Maine recently rendered its first decision affecting private fire protection service. The Portland Water District entered a complaint alleging that its rates for this class of service were discriminatory and asking for the establishment of just and fair rates therefor. In its decision the Commission held:

"The furnishing of private fire protection service by a water utility is one of its legitimate activities and constitutes an important part of the general scheme it is intended to serve. This service can no more be rendered without the existence of a completed plant than can any other service. The plant investment upkeep and operation is as essential to this as to any other. As between this and the other classes of service rendered by the utility, there is no reason why either class should be exempt from carrying its fair proportion of the whole burden. There is no more reason for exempting owners of these sprinkler systems from meeting their proper share thereof than any other patrons of the city waterworks."

In Wisconsin in a number of cases some phase of private fire service was involved, but in only eight of these did any question as to rates enter. These were the Oconto, Green Bay, Janesville, Marinette, Neenah, Ashland, Appleton and Beloit cases.

In the Oconto, Wis., case the question of rates for automatic sprinkler service was dismissed by the Railroad Commission because the only sprinkler equipment connected to the water company's system was to be disconnected

therefrom by the property owner, voluntarily. In at least one or two other cases the commission merely gave tentative approval to existing rates for private fire service. In the Ashland case, involving an entire rate schedule, there were some unusual circumstances which tended to produce rates that would be burdensome to all concerned, including the water company by a low net return.

The Oregon cases decided by the Public Service Commission of that state are reported in that body's Annual Report for the year 1914. The case numbers, reference pages and rates prescribed for private fire protection service are as follows:

Case No.	UF-18	UF-27-28	UF-45	UF-62
Page	142	146	154	176
Monthly charges:				
2 inch or smaller connections	2.00	2.00	2.00	2.00
3 inch connections	3.00	4.50	3.00	3.00
4 inch connections	4.00	8.00	4.00	4.00

The cases as reported do not present any of the reasons or data upon which the above rates were based and do not show whether the costs of making the connections are borne by the utility or the patron. The commission (by letter) states that "no specific rules have been promulgated," and "no specific opinion has ever been rendered concerning this form of service." The Oregon commission is one of those whose jurisdiction does not cover municipally owned plants.

In Indiana the Public Service Commission has had only a few cases in which the question of rates for private fire protection service was involved. That commission's practice has been to allow a charge for that service. No distinction is made between the private utility and the municipally owned utility in this respect.

The commission furnished a copy of its decision in the Terre Haute Water Co. Case (318) as illustrative of its views. In this decision the legal opinions in the cases of Gordon & Ferguson vs. Doran (111 N. W., 272) and Cox vs. Abbeville Furniture Factory (54 S. E.) were cited, and the Indiana commission followed those with very little independent discussion of the subject. Private fire protection service was put entirely on the meter basis by the commission, the charges being dependent on the size of meter and were 50 per cent greater than the monthly minimum charge established for other metered service. The monthly minimum charge for private fire protection service thus becomes as follows:

Size of meter	*Monthly minimum rate*
$\frac{3}{8}$ and $\frac{3}{4}$ inch	$0.90
1 inch	1.50
2 inch	3.75
3 inch	7.50
4 inch	15.00
6 inch and over	30.00

It is found that these charges for 4 inch and 6 inch meters would permit

of the use of 81,000 gallons and 197,000 gallons of water, respectively, per month without extra charges. The company had been in the habit of furnishing the meters but not the service connections. It was required by the commission to provide all service connections free of charge to consumers in the future.

The California Commission, by R. W. Hawley, Hydraulic Engineer, advised under date of February 23, 1917, "There have been no decisions of the Commission, so far as I can find after brief search or can remember, defining qualifications for private fire protection service. There have been a few decisions establishing rates which, at the same time as establishing rates for public fire protection service, fixed a separate and lower rate for private fire hydrant rental.

"Those water companies that have provided separately in their rules for the installation of private fire protection services, generally require that applicant pay the cost. Some of them return this payment if the service is used more than twelve months and the established rates paid. The rate, generally, is one based upon the size of service pipe, as for 2-inch service, $2 per month, and an additional charge of 50 cents for each half inch increase in diameter of pipe."

The statement quoted above is evidently erroneous, for a decision by the California Commission concerning private fire protection service is found in P. U. R. 1915 A-782, being Corona vs. Corona Water Co. In this case the commission followed the readiness to serve principle in establishing service charges.

On February 16, 1917, the chief of Bureau of Public Convenience of the Public Service Commission of Pennsylvania advised: "The Commission has never adopted any rules governing this class of service, '(private fire protection)' nor rendered any decisions covering the matter." However, we find a reference to one decision by that commission in P. U. R. 1916 C-106, being the case of Newcastle Box Co. vs. Newcastle Water Co., in which the commission approved the ready-to-serve principle as a basis of charges for service. This commission furnished the schedules of charges for this kind of service as made by eight of the Pennsylvania water companies, to which reference will be made later.

Apparently the case of Lincoln vs. Lincoln Water & Light Co. (P. U. R. 1917 B-1) is the only Illinois Commission case of interest here. The value of the service furnished by the water company to the owners of private fire service systems seems to have been followed by the commission, rather than the cost of service principle. Considerable space is given to a discussion of distribution of costs between fire protection and general service and the relation of public and private fire service.

After finding the amount of all costs which should be assessed against all fire service the sum is subdivided between public and private fire protection and a schedule of flat rates only is provided for the latter kind, varying with the size of the connection. The schedule rates, which are subject to discounts of 10 per cent for prompt payment, are as follows:

Size of service	*Annual charge (Gross)*
2 inch	$44.44
3 inch	66.66
4 inch	88.88
6 inch	133.33
8 inch	177.77
10 inch	222.22
12 inch	266.66

In See & Depew v. Hackensack W. Co., 1 P. U. C. (New Jersey) 310, the commission passed upon the reasonableness of charges for water service through a 6-inch pipe to supply a private sprinkling system. The annual cost was shown to be between $50 and $60 a year. The cost of the apparatus to the company was about $1,000 and the reduction thereby affected in its insurance premiums amounted to over $300 a year. The cost to the water company of installing a detector meter would be nearly $375. It was agreed that it was feasible to use a detector meter; that the schedule rates for a 6-inch service pipe, with detector meter, was $124 per year, which would more than cover the annual consumption by the company.

It was urged that since the general fire liability is reduced by the automatic apparatus, no augmentation of the plant is required by reason of affording this additional service; hence no additional charge for readiness to serve should be allowed on that score. But the commission took the view that inasmuch as the concern derives a peculiar benefit in increased protection and in reduction of insurance rates, it should in justice pay something additional for the service. The existing schedule of charges for the service was held to be a fair equivalent for the saving thus put within the reach of the consumer.

Court decisions. Decisions affecting private fire protection service have been rendered by about a dozen states, namely: Minnesota, South Carolina, Iowa, Massachusetts, Wisconsin, Kansas, Michigan, Pennsylvania, New Jersey, Missouri, New York and Tennessee.

Gordon & Ferguson v. Board of Water Commissioners, 100 Minn. 343; Ill. N. W. 272; 8 L. R. A. (N. S.) 1049. The plaintiffs, conducting a wholesale merchandise establishment in a large building, installed an automatic sprinkling system, connected at their own expense with the water mains of the municipal plant. When the tank at the top of the building had been once filled, the pressure of the mains would be automatically maintained, and no water would be used unless the automatic sprinkling device were called into play. This connection was not metered because to do so would affect insurance rates. The service pipes for the general water supply of the building were metered and were entirely separate from the sprinkler system. Under the rules of the Water Board, a flat rate was made for water for the sprinkler system on the "ready to serve" principle, and the water used throughout the building from the ordinary taps was charged for at the meter rates. By a separate rule, where the charge for the sprinkler system exceeded the amount due for metered service, the amount of the latter was deducted from the flat sprinkler rate and a bill was rendered for the difference. Refusal of

plaintiff to pay such bills gave rise to the action, plaintiffs contending that a charge for readiness to serve their sprinkler system was unreasonable and that the city had no right to make any charge whatever for that service.

The court said:

"So long as water supplied for protection against fire is a purely public service, under the control and management of municipal authorities generally and under the fire department specifically, no direct charge to individuals is proper. When, however, a sprinkling connection is made with private premises, the situation is materially different. These premises and the primary causes of catastrophe to the building and of the consequent possible use of disastrous quantities of water are primarily under the control, not of the public, but of the owner. A peculiar personal service is provided for his benefit, which is not enjoyed in common by the community in general, but is available only to a limited class of individuals. As a matter of good sense the property owner beneficially employs the water mains for his own purposes and to his own advantage, although he may not, except in case of fire, actually draw any water from the pipes. It is necessary and proper that he should pay. In effect he gets something of pecuniary value from another, which that other is not compelled to give except on the basis of contract. The conclusion is reached that a charge can be made."

It should be noted, however, that the court also holds the rule for deducting metered charges from sprinkler service bills is discriminatory and void, because lacking uniformity in principle and in operation.

Cox. v. Abbeville Furn. Co., 54 S. E. 830, 75 So. Car. 48. In this case the city owned the water plant, but contracted with a power company to operate it as agent of the Board of Water Commissioners. One of the provisions of the contract was that the company should supply the city with water for fire protection free of charge. There were fire hydrants near defendant's premises, but for further protection defendants installed an automatic sprinkler system, connected with the city mains. The company rendered bills for defendant's ordinary metered water and additional bills for the sprinkler service and on defendant's refusal to pay the latter, suit was brought.

It was held that there was no obligation to furnish water without charge for any fire protection other than the regular city system, and that a charge for that service was proper whether the water was actually used or merely available for use. The court says that the benefit to the defendant "comes as the direct result of an appropriation of power and water, which is the property of another and the law implies a promise to pay the reasonable value of the protection thereby obtained." The fixing of a charge on the basis of the value of a service to the recipient thereof is not, however, in accord with the generally adopted "cost of service" principle for rate making.

In Muscatine W. W. Co. v. Lumber Co., 85 Iowa 112, 52 N. W. 108, the defendant agreed with plaintiff to pay a stipulated sum annually if the company would extend its mains as far as defendant's mills and install 4 fire hydrants. Under its contract with the city plaintiff received a certain sum for each hydrant in the municipality, but was not obliged to extend its mains to that point. Defendant made no use of the water for private purposes, but merely wished to have fire protection available. It was argued that plaintiff

exceeded its powers in requiring a contract to pay compensation in excess of that paid by the city for the maintenance of fire hydrants. But the court said that the benefit derived by defendant being peculiar to itself it was competent for it to offer an inducement by way of extra compensation, and by getting a protection against fire in excess of that offered by the city, it became liable for the reasonable value of the service.

Shaw Stocking Co. v. City of Lowell, 199 Mass. 118, 85 N. E. 90, involved a regulation of the water board requiring all water taken from the city's mains for private fire protection service to pass through a meter installed at the expense of the owner of the premises. The city made no charge for water used in extinguishing fires, and the sole object of the rule was to prevent surreptitious or careless use of the water for other purposes. The rule was put in force gradually, beginning with the most important cases.

It was held that there is nothing unreasonable in requiring plaintiff to pay for the installation of a meter in its private fire service pipes, since defendant has afforded reasonable facilities for extinguishing fires by public hydrants, and if plaintiff desires a private system for further protection of its own property it is not unfair to require it to install a meter so that the city may have means of checking wastage. The duty to supply water at reasonable rates to all takers without discrimination does not carry with it the obligation to supply water free of charge for plaintiff's private system of safeguarding its property.

State v. Gosnell, 116 Wis. 606, 93 N. W. 542, is cited in the opinion of the Massachusetts court to the point that it is proper to require consumers using service pipes above a certain diameter to furnish meters and to leave it optional with the users of smaller pipes, that not being an unreasonable classification. See also, *Cooper v. City*, 80 Kan. 121, 102 Pac. 244.

In City of Kalamazoo v. Standard Paper Co. (Mich.), 148 N. W. 743, it appeared that the defendant had established openings in its automatic sprinkling system, whereby water might be drawn off without being metered, and water was taken for ordinary uses by employees without the knowledge of the company. It was impossible, of course, to prove with certainty the exact amount of water taken. Plaintiff was held to be entitled to collect compensation for the highest amount of water which could have been made use of by means of the unlawful taps and by-passes, and a verdict for $15,840 for four years taking was sustained.

In Borough v. Gas & W. Co., 246 Pa. 232, 92 Atl. 142, it is held that on principle a rate fixed by a water company for fire protection service should bear a reasonable proportion to the rates established for other service and where the result of the new rate would give a return of only 4½ per cent on the value of the plant used in such service, the new rate was not unreasonable. And there being no proof of similarity in the conditions, it was not error to exclude proof of rates for fire protection in other cities.

Terre Haute Paper Co. v. Terre Haute W. Co., 110 N. E. 85, was an action to enjoin the water company from cutting off the water supply to plaintiff's automatic sprinkler system. The company was operating under a schedule of rates established by agreement between it and the city. Certain meter rates were provided for in the schedule and it was further provided that for

all purposes not covered by meter rates the charge should be at meter rates on the estimated quantities used. Plaintiff's sprinkler connection was not metered. The court also found as facts that the installation of a meter would lessen the pressure and diminish the flow of the water, which in turn would adversely affect the fire insurance rating of the property; that there was nothing in the rate schedule applicable to the situation as regards sprinkler service; that the paper company was willing to pay the meter rates for the amount of water used, to be estimated instead of metered, but that the water company had demanded that meters be installed for the sprinkler service and that plaintiff pay a fixed charge of $300, plus meter rates for all water used, whether any water was actually used or not, and threatened to shut off the water if its demands were not complied with.

Construing the ordinance as being broad enough to call for the desired service the Court held that plaintiffs were within their rights in demanding a supply in accordance with its terms; that for such service as that required by plaintiffs, the ordinance contemplated that water be served without the use of meters, at meter rates, the quantity used to be estimated by some such process as pumping it first into a tank of measured capacity. The fact that a general fire protection is furnished by the city affords no reason why the water company should not be compelled to supply water and pressure for additional private protection, so long as the taker is willing to pay for the additional service at a reasonable rate. But that rate, like all others, must be based on the cost of the service rather than on its value to the taker. Injunctional order granted.

In Edgerly & Co. v. City of Atumwa (Ia.) 156 N. W. 388, it is held:

1. The proprietor of an automatic sprinkler system derives a benefit from the system in added fire protection and reduced insurance rates, and some benefit being thus conferred by the "readiness to serve," charges may properly be made for that feature.

2. In order that there may be no discrimination between patrons similarly situated, rates for private fire protection service should not be left to be made by individual contracts with each patron, by private treaty, but should be fixed as a part of the regular rate schedule, and applied to all takers under similar conditions.

3. Payment on the basis of the amount of water actually used at meter rates, would be a wholly inadequate compensation for the pressure required and the readiness at all times to serve and the inspection by the water utility which might well be required. Moreover, meters are objectionable, because they impede the flow of water. The service cannot be compared with that rendered to customers generally. Readiness to serve is agreed to be a proper element to be considered, at least by all authorities who hold that any charge at all may be exacted. Of course the amount of water used should be taken into account as well as any saving to the utility by reason of the saving on the general hydrant system in event of fire. But no element of benefit to the owner of the property should be taken into account.

The rates in force were held not unreasonable.

DECISIONS OF COURTS AND PUBLIC UTILITY COMMISSIONS

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APPENDIX 7

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DISCUSSION

J. N. CHESTER: The work of the Committee deserves the heartiest approval. For many years we have had interminable discussions of remedies for our troubles with private fire protection services, yet these discussions never led to anything tangible, anything that helped us. With the presentation of this report, we are arriving at conclusions of value to us in our future work. In considering the report it should be borne in mind that it is a general discussion of a very big subject and that the application of general conclusions to individual problems often requires some modification of those general conclusions to fit special conditions. It is with this thought in mind that the speaker suggests certain modifications or extensions of the Committee's general recommendations.

The conclusions might be revised to advantage, the speaker believes, by eliminating any statement or implied statement that every private fire protection service need not have a detector meter. Where dependence is placed upon inspection to ascertain the use made of fire service lines into private property, there is a strong probability that the facts of such use will not be known. Such a meter is essential, a fact that leads to serious questioning of the advisability of by-passing it. It is true that the by-pass valve can be sealed, but there are doubtless many superintendents present who have found, as the speaker has found, that such sealed valves are not always in the condition they should be. The best policy is to allow the consumer to use all the water through his fire protection line that he desires, provided he will pay for such use, for in that way the money invested in the service will be yielding the largest return of usefulness. The detector meter will show what should be paid for this water, and there is no other method of determining it fairly. Only two months ago water was turned into a private fire protection service on a system with which the speaker is connected, and the detector meter showed later that $80 worth of water had been drawn through the service, although the officials of the company served were unaware that any such use of water was being made. The detector meter is an infallible judge in such a controversy but

reliance placed on inspection would not have been justified by the conditions of this case and what use would have been a sealed by-pass with the seal broken in fixing the sum due for the water used? If anybody desires to attach the Bond Alarm to the fire protection service as an additional safeguard there is no objection to that practice. But the merits of that device do not affect the practical need of an adequate measuring device on every service of this nature.

Some modification or amplification of the Committee's conclusions regarding the size of fire protection lines is possibly desirable. The Committee says that such a line should not be more than half the size of the street main to which it is connected. There are other things to be considered, such as the number of sprinkler heads, hydrants and hose-connections on stand-pipes. In fixing rates by the rational method of imposing a service charge plus a supply charge, an unnecessarily large private fire line may cause much friction with a consumer. The speaker recently found a 6-inch fire service running into a small planing mill with 1800 sprinkler heads. The service charge for such a line was $600 and the consumer naturally complained bitterly, claiming that the fire underwriters insisted on a 6-inch pipe although a 3-inch line would have been large enough. Cases like this show how desirable it is for the Association to adopt more definite conclusions regarding the size of fire protection lines than the Committee has proposed.

The Committee's recommendation that the charge for private fire protection hydrants should be the same as for public hydrants also needs some modification to meet the case where there is a charge for public fire protection based upon the mileage of mains as well as the number of hydrants. In several Pennsylvania cities there is a charge of only $7.50 per hydrant, the remainder of the fire protection revenue being derived from a charge per mile of pipe to which the hydrants are connected. Take the case where the hydrants are 150 feet apart and the charges have been worked out on that basis. To protect a mill on that street only 50 feet of 6-inch pipe, say, must be run on private property. The $7.50 plus the charge for 50 feet of pipe is not enough in such a case.

The work done by the Committee has been admirable and its report is one of the best the Association has ever had. It is in no spirit of criticism but solely for the purpose of enabling the Committee to consider the discussion of its recommendations before reaching its final conclusions that the speaker moves that the Com-

mittee be continued and requested to present at a later date any changes in its report which it may consider advisable.

The motion was seconded.

F. W. CAPPELEN: The speaker regrets that he must vote against this report, although it is excellent in most particulars, because he is a member of the State Board of Health of Minnesota which has passed a resolution prohibiting connections of any sort whatever between mains carrying supplies of pure water and those carrying impure water. The use of a check valve as suggested by the Committee will not be permittted in Minnesota. The Board which reached this decision includes two engineers, both members of this Association, as is its director of sanitation. The decision of the Board was based on sad experience in many cases. Only last year there were eighteen cases of typhoid fever with six deaths, in one Minneapolis establishment where such a cross-connection resulted in the use of polluted water. In a general way the speaker is in accord with the views expressed by Mr. Chester.

H. C. HODGKINS: The remarks by Mr. Chester regarding the influence of fire underwriters on the size of private fire service mains deserves strong endorsement. The speaker has found occasionally that his plans were criticized because of the requirements of the fire underwriters, which apparently made other arrangements necessary. If he wished to install a pump he was told that the underwriters required certain standpipe units or certain duplicate transmission lines to be provided. A situation has arisen as a result where it is very desirable for some strong and influential organization like the Association to go on record as to the technical requirements which sound engineering really warrants in fire protection matters. Then the client will know what additional expenses he must incur in order to be protected against every possible contingency which has ever occurred to a fire underwriter, and can decide whether such sums are justified in his case.

F. E. BECK: A recent experience of the Consolidated Water Company of Utica, N. Y., with detector meters shows their value. In January nineteen of them were installed on private fire protection lines which showed that the flow of water ranged from a minimum of 20 cubic feet per day to a maximum of 5700 cubic feet. The value

of the water registered by the nineteen meters was $3,343 annually. There are 230 private fire protection services in the city, and it is estimated that they should yield a revenue of about $51,000 annually.

MAURICE R. SCHARFF: The section of the report on the charges to be made for private fire protection, if adopted, will place the Association on record as committed to the best principles that have been developed with respect to rate making for water supply. The speaker's company has had occasion to present rate schedules based on substantially the same principles to the Pennsylvania Public Service Commission in a number of cases, and it is gratifying to be able to say that those principles were approved practically in full and rate schedules based on them are now in effect. There are a few features of the Committee's recommendations on this subject with which the speaker differs, however, and these he desires to submit for its further consideration.

In subdividing the gross revenue in order to establish fire protection charges the Committee first set aside miscellaneous revenue and then allocates the remainder to revenue from fire protection and that from general service. The next step is to subdivide the revenue from general service into fixed or capacity revenue and proportional revenue. The service which a water plant furnishes for fire protection is a stand-ready service of exactly the same character as the stand-ready service furnished to the general consumers. Hence it seems more logical in establishing a basis for fire protection charges to reverse the steps proposed by the Committee, which has been the practice of the office with which the speaker is connected.

The Committee recommends that the water utility should pay for that part of the private fire protection line between the street main and the property line, and also that "private fire hydrants shall be charged for at the same rate as public fire hydrants." The logic of this is not evident; the Committee does not recommend that the water utility shall pay for the sprinklers, stand-pipes, fire hydrants and other accessories within the property line. The hydrant rental for public fire protection may well be supplementary to a charge based on the mileage of street mains, as mentioned by Mr. Chester, and it is ordinarily based on the cost of installing and maintaining the hydrants. In the case of hydrants for private fire protection, the cost of installation is borne by the owner of the property. Hence, if the service charge for private fire pro-

tection, based upon the capacity of the pipe used for the connection, is determined fairly and includes the proper proportion of all fixed capacity costs, then there seems to be no occasion to charge for the hydrants.

D. A. REED: This Committee was appointed on account of the great diversity of opinion concerning private fire protection services and it has done excellent work in clarifying the subject. The report only reached the speaker today; doubtless there are other members who have not had enough time to give to it the study it deserves before they vote on its adoption. The discussion shows that members of large experience do not agree with all the views of the Committee, and it is evident, therefore, that the motion to continue the Committee should be carried. The Association now has before it a report of such high character and comprehensive scope that by studying and discussing the recommendations which are made, we should be able before long to agree upon conclusions which can be presented to both consumers and to public officials as representing the mature judgment of the national organization of water works specialists of all classes.

It is true, as already stated, that the Minnesota State Board of Health has barred dual services which are cross-connected. This prohibition is effective, however, only so far as the Board's authority runs. The City of Duluth is still permitting dual service if it is protected by the type of check valve recommended by the Committee. Nobody should criticise the State Board of Health for looking at this matter from the viewpoint of health; that is its duty. Public health is paramount and deserves every practicable consideration, but if health alone had been considered in the recent war Germany would never have been defeated. We cannot board a train or cross a crowded street without taking some risks. The dual system of water supply protected by the type of valve recommended by the Committee has never been the cause of sickness so far as widespread investigation has shown.

F. C. JORDAN: Several speakers have referred to the portions of the Committee's report regarding the size of private fire protection services. The report states in one place:

"The size of private fire service connections which should be permitted depends not alone upon the adequacy of the means for con-

trolling them to prevent bleeding of the water system, but also upon the design and capacity of the water distribution system in the vicinity of the risk."

That statement shows the opinion of the Committee that the superintendent's common sense and good judgment must be depended upon to determine from the conditions of each case what size of private service can be allowed. The Committee's suggestion to limit the size of a private fire connection to half the size of the street main was merely a suggestion of a maximum limitation for cases where the street mains were not large, and manifestly is not intended for application where one of the largest pipes of the distribution system passes through the street.

The purity of the water supply has always been considered paramount to the fire service by the Committee. The obligation of a water department or company to deliver to the public a supply of water which can be used without danger is greater than its obligation to furnish a supply for private fire protection. The Committee gave this subject careful study and reached its conclusions after thorough investigation, and it believes the purity of the supply will not be affected if its suggestions regarding dual systems are complied with. No modification of those recommendations which will diminish the safeguards they place about the quality of the potable supply should be made without the most careful study of all possible consequences that may follow their adoption.

As a member of this Committee the speaker desired to put on record his appreciation of the work done by Mr. Hill, its chairman. The members of the Committee assisted in the gathering of information but the preparation of the report was his work, and its excellent preparation is possibly even more evident to his associates on the Committee than to the other members of the Association.

PATRICK GEAR: There are two features of this excellent report with which the speaker cannot agree. The first of these is the recommendation that a private fire service should be carried to the curb line free of charge to the owner of the property served. If the owner desires a private fire service he should pay for the whole of it, for it is something supplied for his individual use and not for the public benefit. Domestic consumers pay for the entire service connection and there seems to be no good reason for changing that plan in the case of private fire protection lines.

Check and gate valves have interested the speaker a great deal for years. Last winter fire insurance agents requested the installation of double check valves on every fire service in Holyoke. The speaker refused to support this request because the use of double check valves meant too much expense when one good check valve, well made and installed, should answer the purpose.

CHESTER R. MCFARLAND: If the Committee is continued, as it should be, it can profitably enlarge its recommendations regarding the size of private fire services. It is desirable for water works officials to know, for example, how many fires there are annually in sprinkler-protected buildings and how many heads opened during such fires; what have been the largest fires in sprinkler-protected buildings and how many heads opened during them; and what is the largest percentage of heads that have opened during a fire. This is a feature of the subject that is equally important to the water works superintendent and the owner of the plant to be protected. It is manifestly unnecessary to run a 10-inch main into private property if the maximum number of sprinkler heads which it is reasonable to expect to be open at one time is 75. Should not the number of sprinkler heads which there is any probability of being open simultaneously determine the size of the private fire protection service rather than the total number of heads that are installed?

W. H. DITTOE: The Committee is to be congratulated for having presented one of the most complete and valuable reports submitted to the Association during recent years. The subject has been treated frankly and many questions have been met squarely which other discussions of this problem have avoided entirely. Those who are engaged in the effort of maintaining the purity of water supplied are gratified in the summation of the findings of the committee on the physical questions involved in private fire protection service, particularly in the first, second, and fifth conclusions enumerated. From the standpoint of insuring the safety of a public water supply as it is delivered to the consumer, there can be no argument favoring the establishment of any connection which introduces even the most remote possibility of the entrance of polluted water into the public main. The aim should be to render such occurrences impossible. It may be argued that under certain circumstances a

direct connection is necessary to provide the primary supply adequate for fire protection. If such argument is accepted, however, and the installation of a connection equipped with check valves and an alarm valve as shown by figure 11, is agreed to, it is vitally necessary that two conditions be met: First, the use of the connection must be restricted to fire protection only, and there must be no flow through the connection to furnish water for industrial purposes or other regular use. It is well known that a so-called breathing check valve soon becomes incrusted and ineffective in preventing back flow. It is also important to recognize that care is necessary to prevent the establishment of connections on the mill side of the check valves for furnishing water for purposes other than fire protection. Second, frequent careful inspections of the check valves and alarm valve must be made by the water works officials. While such inspection may be possible in cities of considerable size, there is serious doubt of the practicability of securing regular and thorough inspection in all cases.

In 1915 the Ohio State Department of Health was requested to approve fire protection connections to the distributing system of a small municipality, the proposal including the installation of factory mutual check valves. The municipal water supply was being obtained from wells and was of excellent quality, and the mills maintained also an auxiliary fire protection supply obtained from a polluted stream. After careful investigation of the proposal, approval was withheld, but the installation was permitted for trial and temporary use. Conditions were attached prohibiting the establishment of any connection on the mill side of the check valves whereby water might be taken from the fire service distributing system for industrial use, and requiring that the installation be properly tested by the water works superintendent at intervals not greater than one week until the watertightness of the check valves had been indicated, and thereafter at intervals not greater than thirty days. The experience in this case has been that the water works superintendent has failed to make the inspections required. One inspection was made by a representative of the State Department of Health, at which time the check valves were found to be tight, but there has been no regular and thorough inspection made during the four years which have elapsed since the installation was made. The absence of data secured by inspection renders uncertain the safety of the public water supply of the community. As a result of this experience, the

Ohio State Department of Health is not inclined to favor the installation of similar connections. Obviously, the safe course to pursue is to separate the public supply from the independent supply so as to preclude possibility of back flow, as recommended in the fifth item of the Committee's conclusions.

While the report is restricted to a discussion of fire protection connections, it may not be amiss to mention the danger introduced by the establishment of connections from the public mains intended to furnish water for mill purposes. Where an independent supply is maintained by the mill, the only safe procedure in establishing such service connections is to require complete separation. Check valves in this instance are unsafe, regardless of precautions which may be taken through frequent inspection.

W. E. Miller: The chairman of this Committee has very graciously passed a generous share of the credit for the preparation of this report to the other members, and stated that he was unable to name the one to whom most credit was due. The speaker can furnish this information, by saying that the labors of the chairman must have been at least as great as the sum of those of all the other members, for his was the task of assimilating all of the material furnished by the other members and producing the draft of the report as here printed. The membership should not only appreciate the magnitude of his labor in this connection, but should know that it has also meant a very substantial financial expense to him personally, over and above the Association's allowance for committee expense. The Association ought, so far as possible, to relieve its committees of personal financial expense in connection with their work for the Association.

This Committee has labored, as many committees do, under the serious disadvantage of having its members widely separated and therefore unable to get together as much as was desirable for discussion of the differences of views which existed. The existence of some differences of opinion among the members of the Committee leads the speaker to indicate wherein his own views differ from what a reader of the report is likely to understand it to present, advocate and recommend. The report may, to an extent, make provision, as is claimed, for the somewhat different view which the speaker holds, concerning the method of determining proper charges for private fire protection service, but without attention being again called

to this view it is somewhat doubtful that it will not escape the attention and consideration which he firmly believes it deserves.

A reader of the report is not altogether unlikely to understand that proper charges for private fire protection service (such service being assumed to be separated from other commercial or industrial service in the same premises) should include a share of the utility's capacity costs incident to investment in and operation of the pumping plant, main pipe system, etc., as well as charges incident to the utility's investment in fire service connection (including meter if provided) and its maintenance. No such erroneous conclusion is or ever was intended by the speaker to be admitted or advocated.

By the most recent and most careful re-examination of the report it is found that the difference is traceable back through the report to what is surely a mis-statement of fact under "Definitions." There it is stated that "it (private fire protection service) may be defined as furnishing water for an individual, firm, or corporation for special fire protection, in addition to that furnished by the water purveyor through the hydrants placed upon the public streets." This statement or definition may be made more correct by eliminating the two words "addition to" and inserting in their places the two words "*lieu of*."

Statistics referred to in the report itself are admitted to show that 70 per cent of all the fires occurring under sprinkler systems are conquered and subdued without any aid from the fire departments. In these cases at least (a substantial majority of all) the water furnished to the automatic equipments was not in "addition to that furnished through the hydrants placed upon the public streets," for the prompt and effective action of the automatic sprinklers relieved the fire departments and public fire hydrants of any work to do in those cases. The supplies or quantities of water furnished in these cases to automatic sprinkler systems were in *lieu of* the much larger volumes of water which would undoubtedly have been necessary from public fire hydrants had there been no such prompt, effective and automatic application of water to the fires while they were small and undiscovered.

It is also undoubtedly a fact susceptible of proof that in many if not most of the instances included in the remaining 30 per cent, the water furnished to automatic sprinkler systems and by them applied to these fires promptly and in their incipiency held the fires in check and greatly reduced the total volume of water required for the sub-

jection of the fire in each case. It is therefore impossible to escape the conclusion that the definition is fallacious as it stands and needs the modification already indicated.

The old contention that loss of control of water supplies to private fire protection systems occasionally occurs and produces a drain upon the main pipe system so serious as to disable the general fire protection, or hydrant service, and that such situation warrants a very substantial demand charge is also fallacious, for the reason that such situations are preventable. They occur only rarely and then only as a result of the absence of available and dependable facilities which could and should have been provided. The absence of proper facilities for reasonably foreseen emergencies, and the consequent dangers resulting from such lack of facilities, are not a proper basis for service charges, while their provision and care would be.

The prevention of loss of control of public water supplies to private fire protection systems does not depend upon the possible future development and perfection of a new type of valve which can be controlled from a distance or which will automatically close when the flow of water through it reaches a predetermined rate. For many years there have been in successful use, on standpipe connections, valves and auxiliary devices for their remote control. The distance through which their control may be effected is great, if not practically without limit. Their remote control involves an electrical circuit, and it is upon this feature alone that the distance through which remote control is obtainable depends. Many standpipes, elevated tanks and high reservoirs connected to water main systems and located at considerable distances from the pumping stations which supply them are equipped with such valves for the purpose of enabling the operating engineer to shut off such storage quickly and on short notice and pump direct into the mains alone under increased pressure for fire service. To all appearances and so far as now known such valves have been found quite reliable. There is no apparent reason to question their applicability to the service connections for private fire protection or for large industrial supplies for the purpose of preventing loss of control which might otherwise occur in time of fire.

Speaking comparatively, entirely too much stress has, for years, been laid upon the danger to the general fire protection service attending a possible loss of control of water supplies to private fire systems in times of fire. The fact that most cities whose water works

furnish private fire protection service have industrial service connections fully as large as those for (separate) interior fire protection seems to be quite generally ignored. One kind of service connection is no less dangerous in this respect than the other when they are of the same size and are supplied from the same mains. Instances could probably be found, if an inquiry be made, of industrial establishments having both kinds of service connections and using a larger pipe for industrial or manufacturing purposes than for interior fire protection. In such cases, obviously, the loss of control of the former in time of fire would be more serious than that of the private fire line, assuming that both are connected to the same main as they probably would be.

The report is likely to leave with a reader the impression that the water works patron with a private fire service connection wants merely capacity while one with perhaps an equally large connection for other purposes wants water (see page 727), and therefore a proper charge for interior fire protection should include some of the utility's capacity expenses. Such an impression is erroneous for the reason that the more efficient interior automatic fire protection will, in general, make use of only a portion of the larger volume of water which would otherwise be necessary from public fire hydrants, and the hydrant rentals should therefore cover all of the water works capacity expenses incident to all fire protection service.

If the hydrant rentals are not at the approximately correct level the tax payers do not pay what they should for the public fire protection service furnished by the water works. The objection to, in such cases, putting more of the water works expenses into the rates for private fire protection service is that the effect would be distinctly discriminatory between tax payers with and without interior fire protection, irrespective of the discrimination existing between tax payers and water takers. It is assumed here that all recipients of private fire protection service are the owners of the protected premises and therefore tax payers. This is believed to be substantially true, although it may be that exceptions could possibly be found.

The quotation from the Maine Commission's decision in the Portland Water District case presented in the committee report will, doubtless, be understood to have been presented for the purpose of arguing the existence of a moral obligation on the part of owners of dangerous fire risks to install automatic sprinklers. (See page 723.)

Here arises the questions as to what are the dangerous risks and

what bearing the contention has upon fire risks which are dangerous in themselves but are isolated from any and all other combustible property and therefore not dangerous to other property owners. The danger from serious fires attends all combustible property in a wide range of degrees, with but little if any indication as to where the classification line is to be drawn between risks whose owners are under moral obligation to provide automatic sprinklers and those who are not. The tendency as time goes on, will surely be to include more and more property in the class which should have special interior fire protection. Even frame dwellings in populous districts may, at no greatly distant date, be so classified, for it must not be forgotten that fires occurring in such properties during periods of high wind have been and probably will again be the beginnings of great conflagrations.

The remarks by the Maine Commission quoted in the committee report have, at best, but a very remote bearing on any of the fiscal questions discussed therein. These questions should be viewed wholly from the standpoint of making a new, complete and equitable schedule of rates for a water works, by a logical and wholly defensible distribution of what is first found to be a proper amount of gross revenue among all the consumers. The heretofore prevalent idea of getting out of the furnishing of private fire protection service the maximum possible amounts which could on any basis be held reasonable is entirely wrong and should be abandoned. When viewed from the standpoint here urged it will, theoretically, at least, make no difference to the owner or operator of a waterworks, what proportion of his proper gross revenue is allocated to this service in the construction of a complete rate schedule.

Concerning the recommendation in the report that charges for service to private fire hydrants should be the same as for public hydrants, it may be pertinent here to call attention to a fact presented in one of the appendices to the report, namely that the Wisconsin Commission has on various occasions held that it is the duty of municipalities to provide and pay for all fire hydrant service, including that from hydrants located in the yards of industrial establishments. The decision of that Commission in the Beloit case is one of the more notable ones in this respect. (7 W.R.C.R. 187, 336, 341.)

Although the Commission stated, in the above mentioned decision, "The cost of such private fire protection service" (outside hy-

drants), "if any, is a matter to be adjusted between the city and the consumer receiving such service," it would probably be found impracticable for a municipality to collect special charges for fire hydrant service from some industries, separate from the general taxes, and not from other property owners,—on the ground that it would be discriminatory, and therefore illegal.

Notwithstanding the foregoing comments, it is recognized that in some cases, it may, perhaps, be advisable, owing to non-existence of state regulation of water utilities and to other conditions, to follow the recommendation in the committee report concerning this matter.

Concerning question 3, page 692, it should be kept in mind that what is there said concerning private fire service connections applies equally to connections of the same size for industrial service and with even more force to industrial service connections of larger diameters. It is also to be borne in mind that the possibly disastrous effect of bleeding of mains in the vicinity of a fire, due to broken connections or interior piping systems, is of much more serious consequence where dependence is placed upon hose streams direct from fire hydrants than where portable fire engines are used.

In conclusion, it will be repeated that so far as the delivery of water for fire protection, of any kind, to the immediate vicinity of any fire risk is concerned, the expense thereof should be covered by hydrant rental charges, and that where hydrant rentals received by water utilities are not now sufficient to cover such costs they need revision and should get it.

At the close of the discussion Mr. Chester's motion was put to vote and carried.

THE EFFECT OF THE WAR PERIOD 1914–1918, AND PUBLIC CONTROL UPON THE WATER WORKS OF THE UNITED STATES[1]

By Leonard Metcalf

Some months ago the Executive Committee of the American Water Works Association asked the author to prepare for this Convention a paper upon "financial control . . . . and war-time rulings of public service commissions and capital issues committees on water works conditions, with references to such related subjects as deemed pertinent," that, as suggested by President Henderson, there might be induced such discussions "as necessary to crystallize those results of war-time activities or stagnation, which have affected water works administration, to the end that managers may carry out the readjustment of their work to meet normal conditions in the best manner possible."

In response to this request the author has reviewed five hundred decisions, more or less, affecting water works, handed down by courts and commissions during the four and one-half year period from January, 1915, to May, 1919, hoping to be able to report to the American Water Works Association their more salient points, or at least the present tendencies and the influences upon them of the war period. The task proved too big for the time available, and the author is therefore obliged to limit his comments to the impressions left by his investigation, rather than to attempt an exhaustive analysis of the decisions reviewed.

Public ownership is less attractive to the people in the light of recent experience in public administration of public utilities in construction work—of the Emergency Fleet Corporation, the Housing Corporation, the Railroads, the Construction, and other divisions of the army at home and abroad—and of the advance in prices of labor and materials. The condition and service of the railroads and of the electric traction properties are far from satisfactory, and their present financial problems seem almost insolvable. Many of the

[1] Read at the Buffalo Convention, June 10, 1919.

great water works systems are in difficult positions financially. The government itself, as evidenced by the utterances of Mr. McAdoo, Mr. Hines and many others, has recognized the decline in morale under government ownership. The attitude of the great daily papers, the country over, in text and editorials, appears overwhelmingly opposed to its extension. Even the utterances of the church, through Cardinal Gibbons, reflect the same view.

The jurisdiction of the commissions in public utility regulation and control is constantly becoming more nearly complete. As the courts limit their action largely to questions of principle, reversals in the interpretation of fact by the commissions are rare. The practical effect of this, from the layman's viewpoint, is that, if the decision of the commission is sound in statement there is little hope of modification of findings, even though the conclusions reached seemed to indicate that no substantial weight was given to certain elements of value or factors affecting it.

Valuation. The commissions continue to tend strongly to original cost, as the fairest measure of value.

Many competent observers believe that past valuations or rating bases have frequently been too low, that the present decline in character or excellence of service clearly reflects this, and that the present rates on money are already, and the future rates will continue to be, higher in consequence of this tendency to undervalue. The difference between actual and assumed value may not always be great, but the tendency is to undervalue, and the influence is therefore usually in one direction. Its result appears likely to be disadvantageous to the public.

The failure of the rates prescribed by certain of the commissions in the past, to yield the revenue intended, gives further evidence that the companies are too often called upon to bear a burden of hazard of loss, disadvantageous to the public.

Overhead allowances have increased substantially, indicating that the commissions themselves, as a result of longer experience, recognize that their earlier allowances were too close.

Going value or development expense. While the recognition and inclusion of going value or development expense as a property element in the valuation of water works for purchase, sale, or rate determination, has been general and consistent on the part of the higher courts, the practice of some of the commissions appears in marked conflict to this position. The older commissions, however, generally

recognize it, though the allowances for it are less than those accorded by financiers and operators in practice and in many actual sales.

Franchise values per se have shrunk markedly in the past decade, by contrast with the previous decade.

Depreciation. The general treatment of the depreciation allowances has improved immensely, as evidence has accumulated, and this evidence has borne out the contentions of water works operators. The practice in the fixing of the annual depreciation allowance is generally fairer than in determining the accrued depreciation, but this difficulty is reduced by using the undepreciated value as the rating base.

The more equitable distribution of the burden of the rates is marked. The commissions have generally been steadfast in their insistence that the payment for fire protection service should be commensurate with its cost and that the distribution as between domestic and commercial or industrial service should also be equitable according to cost, within the limitation of loss of business resulting from raising its expense beyond that at which the industries could supply themselves.

The position of the public service commissions has increased in power and recognition. Their ability and outlook have grown and broadened with experience. The good effect of continuity of service is as marked as is the retrogression due to change, until length of experience and service again make themselves felt.

The mutual respect and cordial relations which exist between the commission and the corporation managers in many states, clearly reflect a better understanding of the real difficulties of the problem and of a desire on both sides to reach workable standards of service, which shall be of common advantage to the public and to capital, to the operators and the employers of public utilities.

The most serious differences of opinion generally arise through lack of understanding or full appreciation of the fundamental factors and difficulties of the problem.

The marked increase in cost of construction and operation, which will be discussed in detail, is also reflected in the growing number of cases of advance in rates granted by the regulatory authorities.

A review of the water works decisions contained in the twenty-four volumes of *Public Utilities Reports Annotated,* published in the four years 1915–1918, indicate the following approximate number of increases granted.

1915.....Increases granted to 4 plants
1916.....Increases granted to 12 plants
1917.....Increases granted to 15 plants
1918.....Increases granted to 67 plants

It is important to note that increases were few until the latter part of 1917, or early part of 1918, whereas the marked increase in cost of construction and operation, to waterworks, occurred in the latter part of 1916 or early part of 1917. This delay of twelve to eighteen months was burdensome to the companies affected, more particularly to those with pumped supplies.

A reading of many of the decisions affecting water works and other public utilities, seems to indicate that it was the effort of the commissions to maintain the financial credit of the corporations, without attempting to make good the entire loss due to the war and abnormal conditions resulting.

THE FINANCIAL BURDENS DUE TO THE WAR WERE BORNE BY THE WATER WORKS

In its report to the 1918 convention, the Committee on War Burdens of Water Works in the United States called pointed attention to the letter of the Secretary of the Treasury, Mr. McAdoo, addressed to President Wilson on February 15, 1918, in which he said:

> I earnestly hope that you may feel justified in expressing the conviction that the vital part which the Public Utilities Companies represent in the life and war-making energy of the nation, ought to receive fair and just recognition by state and local authorities.

and to the reply of President Wilson on February 18, 1918:

> It is essential that these utilities should be maintained at their maximum efficiency and that everything reasonably possible should be done with that end in view. I hope that the state and the local authorities, where they have not already done so, will, when the facts are properly laid before them, respond promptly to the necessities of the situation.

Reference was further made to the fact that the public service commissions and other regulatory bodies in the United States had already shown their appreciation of the serious nature of the conditions confronting the public utilities properties, by granting, in certain recent cases, increase in rates or levying surcharges on existing rate-schedules, after careful review of the local conditions.

The question may now fairly be asked: "Did the regulatory authorities meet the situation?"

The issue is not raised here as to whether they should or should not have met the situation, nor how far sound public policy demanded that rates should be raised to meet the burden of increased expenses, but merely the question of fact, did the commission relieve the public utilities of their increased burdens due to the war?

To this question the answer must be "no," though many substantial increases were granted.

Whatever may have been the theory, principle, or motive governing the action of the regulatory authorities, it is a fact that the relief granted did not cover the change in conditions. It is apparent in the decreased, or suspended, return upon traction, gas, telephone and water utilities. The burden of the tremendous increase in operating expenses, taxes, and cost of money was borne largely by the utilities themselves, by the investor and not by the public, for the time being at least.

The data submitted herein seem to indicate that the increases granted to water works up to 1919, resulted in about a 10 per cent increment in net revenue and that in spite of this increase there was a net decrease of approximately 10 per cent.

The position of the regulatory authorities was a difficult one in view of the abnormal condition of the times and the war needs. Opinion may well be divided as to the limit to which it was wise for the commissions to go in relieving the corporations of their burdensome increase in costs. To the author it seemed, and has always seemed, that such burdens could not practically be removed by the commissions *promptly*, because this would require too frequent revision of rates, but that the burdens should be recognized and distributed over a somewhat longer period of time, through an increase in return giving adequate margin for their amortizaton and for the establishment of reserves to cover the future hazard element.

The fact should be admitted, however, that the hazard of investment was *not* generally removed from the utilities by the regulatory authorities during the war, though relief was granted in many cases which helped to maintain the solvency of the corporations, and this was in some cases, at least, the goal sought.

Mr. Russell Robb, one of the partners in the firm of Stone & Webster, in a paper upon "The Street Railway Situation," pre-

sented to the Bankers Investment Association of America, in November, 1918, makes the following interesting statements:

In spite of the increased costs of operation, the fares in most places have remained the same. The result of this is interesting:

The grocer who formerly gave 2 eggs for a ride now gives about 1.

The farmer who formerly gave about 3 pints of wheat for a ride now gives a bit over 1¼ pints.

The planter who formerly got 2 rides for a pound of cotton now gets 4 or 5 rides.

The miner who formerly gave 40 pounds of coal for a ride now gives about 20 pounds.

The grocer who exchanges his eggs for coal, or the planter who exchanges his cotton for wheat, is about where he was before, except that he deals with larger figures; but practically all the riders of street railways if they paid in the things they produced, would now be giving much less of their product for their ride, and yet all those who contribute toward the providing of street railway service need as much as they did before of these various products and cannot get as much, although they are themselves giving as much of their own product as before. Measured by exchange value, the fares of twenty years ago have been cut in two.

There has been some tendency on the part of public men, even when admitting the difficulties the electric railway managers are laboring under, to read a lesson to them about former extravagance, erroneous practices, bad judgment or speculative building, but these same men are not expecting farmers or planters or miners or manufacturers to sell their product at the prices of twelve or fifteen years ago, and do not twit them on their bad management of their affairs because they cannot live on the old prices.

It is safe to say that electric railways would be quite content today if they could operate under the prices of twelve to twenty years ago with the fares they received then, or that they would willingly pay the prices of labor and material today if they could exchange their product on the basis prevailing twelve to twenty years ago when they established their business. If the projectors of street railways and those who added to the original properties showed bad judgment in their choice of enterprise, it was in their too ready belief that since the public would assuredly insist on lower fares and better service if the trend of prices became downward, they would likewise realize that fares must go up and conditions be alleviated if there were a radical change upward. It has been said that "other businesses do not squeal for help when they fail to make a success; they take their medicine," but business other than utilities, including the railways, do not have to place their property in the hands of the public to regulate. They are free to adjust the price of their product according to their costs, as we see all private business doing today, and other businesses may in time of great trial even shut down partly or wholly or dispose of their plant. There is no squeal for help now, but there is appeal to customers who have the power of making their own prices, to make these prices fair.

EFFECT OF THE WAR UPON WATER WORKS REVENUES AND EXPENSES

The situation with regard to the water works of the United States is probably fairly shown by the following comparative records of about 50 plants with aggregate annual revenue of about $35,000,000 and supplying a total population of upwards of 9,000,000 persons or nearly 9 per cent of the entire population of the United States.

The records made available to this society at its 1918 convention, through the efforts of the Committee on War Burdens of Water Works in the United States and the courteous coöperation of the managers of these works, have been brought down to date, December 31, 1918, by the author, through the further interest and assistance of these managers.

Figures 1, 2 and 3 show the effect of war burdens upon the revenues and expenses of about 50 typical water works in the United States in the period from 1914 to 1918, both inclusive. The relative percentages of the records of each year are shown with reference to the prewar conditions, which existed in the United States up to or slightly later than the end of the year 1915, assembled in four groups characterized as the Eastern the Central, the Southern and the Western Groups of water works, the group percentages being subsequently averaged, to determine the general conditions prevailing over the country.

These records indicate that:

1. The annual revenues *with such increase in rate schedules as were granted by the regulatory authorities and put into effect by the plants*, have increased at an average rate of approximately 7 per cent per annum, slightly less than a normal amount.

2. The operating expenses, including taxes where taxes are paid, and excluding them where none are paid, have increased over the year 1915 abnormally; by 13 per cent in 1916, 33 per cent in 1917 and 52 per cent in 1918.

3. The net (operating) revenues applicable to depreciation, interest, dividends and surplus, have substantially stood still since the year 1915.

The average increase in population in this country has been at the rate of approximately 1.9 per cent compounded annually, and of the cities supplied by these 50 typical water works, about 3.1 per cent.

Gross Annual Revenue

% of Revenue for 1915						
Group	1914	1915	1916	1917	1918	
Eastern	95.7	100.	110.1	112.8	120.6	
Central	98.3	100.	109.1	111.4	126.4	
Southern	97.7	100.	107.5	120.3	126.3	
Western	101.7	100.	107.3	109.5	117.5	
Average	98.3	100.	108.5	113.5	122.7	

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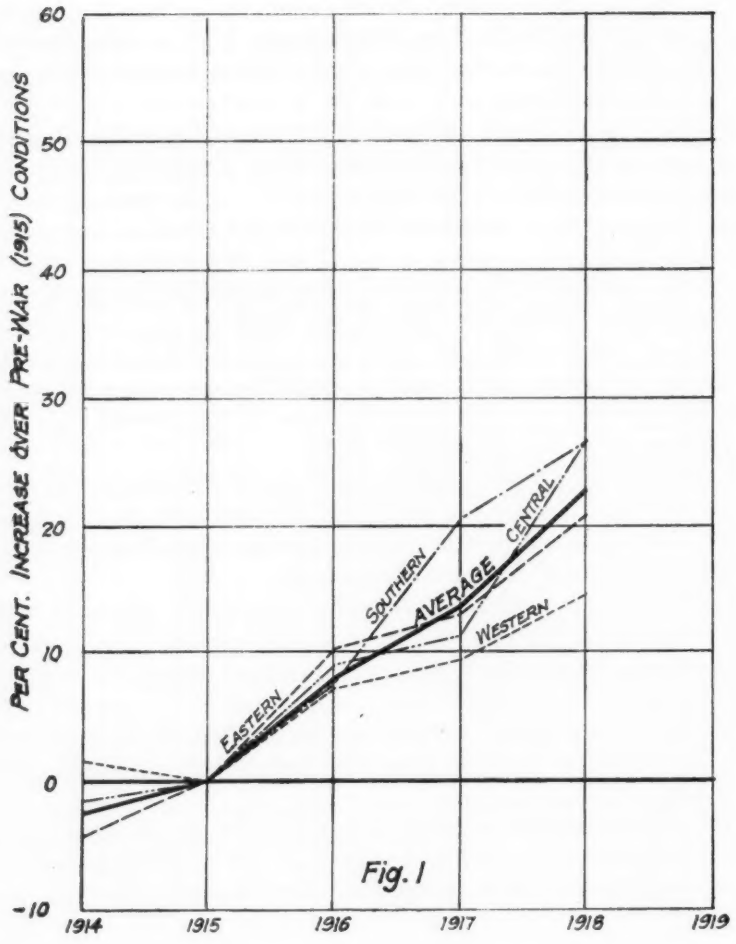

Fig. 1

OPERATING EXPENSES INCLUDING TAXES

% OF OPERATING EXPENSES & TAXES FOR 1915						
GROUP	1914	1915	1916	1917	1918	
EASTERN	99.7	100.	121.9	141.1	149.7	
CENTRAL	100.9	100.	109.5	137.3	162.3	
SOUTHERN	97.0	100.	109.7	134.6	165.9	
WESTERN	98.6	100.	109.9	117.4	128.0	
AVERAGE	99.0	100.	112.7	132.6	151.5	

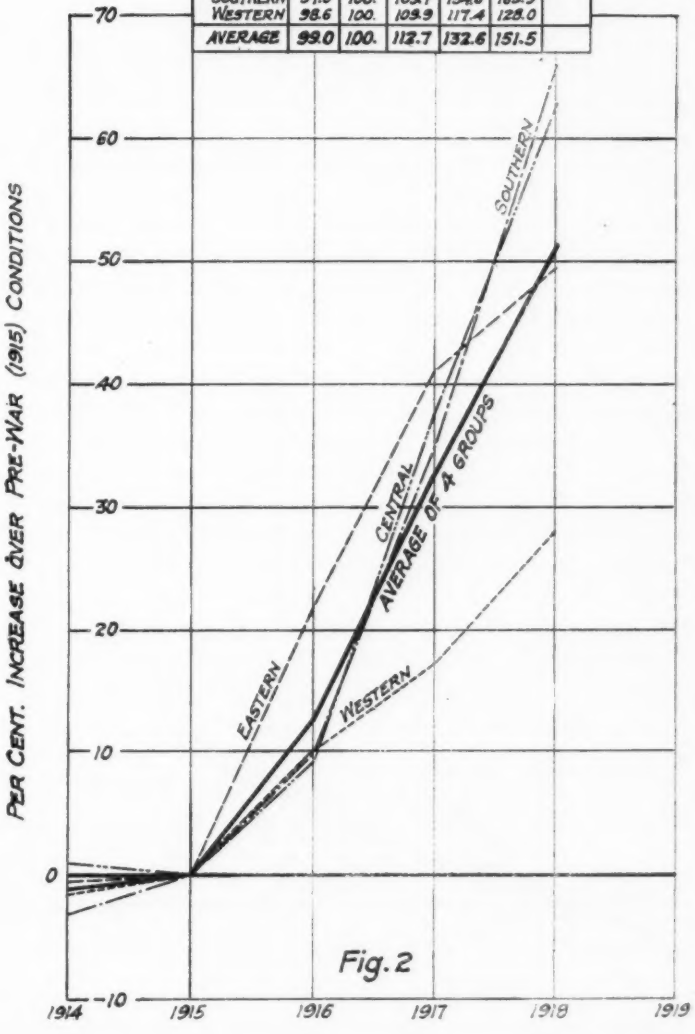

Fig. 2

NET REVENUE

APPLICABLE TO DEPRECIATION, INTEREST, DIVIDENDS AND SURPLUS.

	% OF NET REVENUE FOR 1915					
GROUP	1914	1915	1916	1917	1918	
EASTERN	90.9	100.	103.0	90.4	105.8	
CENTRAL	97.3	100.	110.0	98.5	106.5	
SOUTHERN	97.9	100.	98.3	104.0	89.1	
WESTERN	103.6	100.	104.3	105.3	114.4	
AVERAGE	97.4	100.	103.4	99.6	104.0	

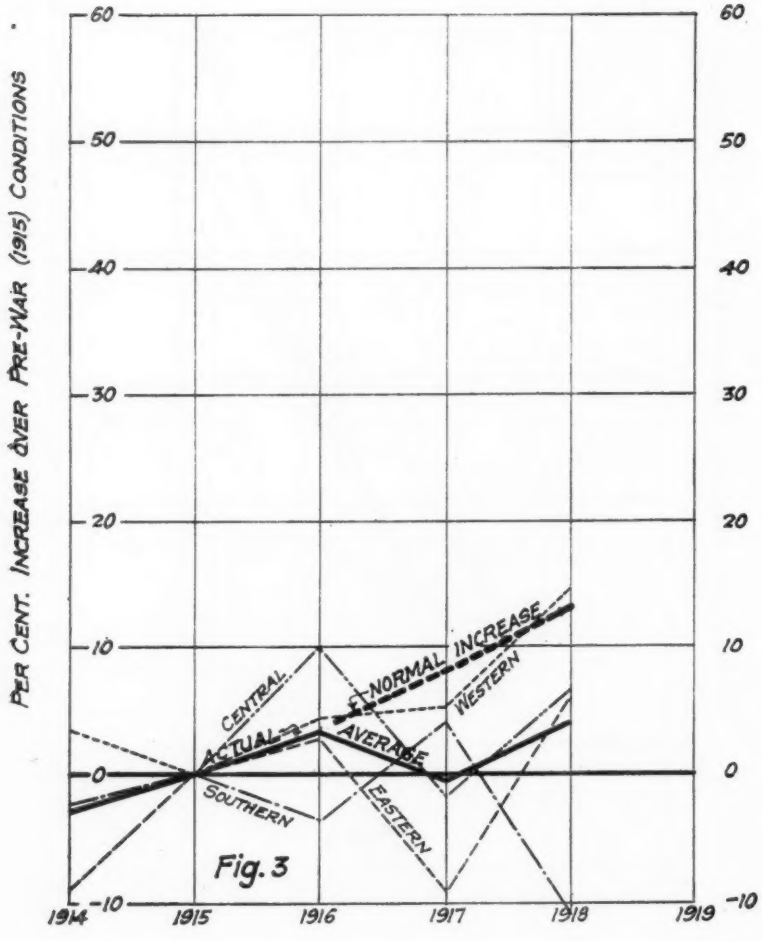

Fig. 3

The net revenue of water works usually increases at the rate of from 4 to 5 per cent[2] compounded annually. Yet the total increase in the three-year period from 1915 to 1918 is but 4 per cent against a normal amount of from 12 to 15 per cent, in spite of increases granted by the Commissions.

The records and figure 3 indicate further that the increases in rates granted to water works by the commissions seem to have amounted on the average to about 10 per cent, serving thus to decrease the loss in net revenue in 1919 from 20 per cent more or less, to 10 per cent, or thereabouts. If this inference is sound, the loss in operation was divided equally between the works and their consumers.

It is clear, however, that the burden of increased operating expenses plus the interest upon the new investment put into these properties during the war period, has been *borne by their owners* in larger measure than by the public, except in the case of publicly owned works.

It is interesting to note further that the adverse conditions in the western group of water works do not appear to have been quite so aggravated as elsewhere in the country. This is probably accounted for by the facts that a larger relative proportion of the water served by the western than by the eastern works—the records of which are here cited—is brought to the consumer by gravity, and that the advance in their labor costs has been relatively less, though they were at a higher point before the war.

Cost of unskilled labor and materials. The relative increase in cost of labor and materials to the typical water works in the United States previously referred to, is shown in table 1. It contains the basic information reported in table 10 of the 1918 report of the Committee on War Burdens in the United States, brought down to December 31, 1918, by the author, through the friendly assistance of the managers of the plants reporting, regardless of public or private ownership.

Unskilled labor costs, in cents per hour, did not generally feel the influence of the war until the middle of the year 1916. As compared with pre-war conditions, reflected by the prices prevailing in

[2] A recent analysis by the author, of the increase in operating revenue (applicable to depreciation, interest, dividends and surplus) in 19 different water works during the five-year pre-war period from 1910 to 1915, showed an *average rate of 4.14 per cent compounded annually.*

TABLE 1

Summary of data upon increase in cost of labor and materials to water works in the United States, as reported to the executive committee of the American Water Works Association May 1918. (Revised April 1919)

ITEM NUMBER	ITEM	NUMBER OF RECORDS	PRICES PER UNIT				PER CENT INCREASE OVER 1915			YEAR 1918 ASSEMBLED BY METCALF		
			1915	1916	1917	Three months 1918	1916	1917	Three months 1918	Number of Records	Unit price	Percent increase over 1915
							per cent	*per cent*	*per cent*			
1	Unskilled labor*—in cents per hour											
	(a) Western group.....	7	27.0¢	28.5¢	31.4¢	Still in-	5.0	16.0	Still in-	8	41.8¢	54.7
	(b) Central group.....	12	21.7¢	25.3¢	26.9¢	creasing	17.0	24.0	creasing	10	37.2¢	71.3
	(c) Eastern group.....	15	23.0¢	26.7¢	30.4¢	in 40.6	16.0	32.0	in all	18	40.2¢	74.7
	(d) Southern group.....	10	17.9¢	20.6¢	24.5¢	all	15.0	37.0	groups	12	34.3¢	91.6
	(e) Average of groups (4).....	—	22.4¢	25.3¢	28.3¢	groups	13.0	27.0		4	38.4¢	71.2
	(f) Average of all.....	44	22.1¢	25.2¢	28.3¢		14.0	28.0		48	38.4¢	73.2
2	Cast iron pipe—per 2000 pounds.....	21	$24.23	$30.70	$51.60		26.7	112.9			$67.74	179.0
3	6 inch valves.....	11	$11.18	$12.64	$19.13	$23.20	13.1	71.1	107.6	23	$19.13	71.0
4	12 inch valves.....	3	$34.78	$41.53	$65.22	$69.00	19.4	87.6	98.7	10	$65.02	87.0
5	2 way hydrants.....	6	$26.69	$32.04	$43.13	$53.90	20.1	61.6	102.0	38	$51.80	94.0

6	Coal per 2000 pounds										
	(a) Eastern group.....	13	$2.98	$3.80	$5.96	$7.04	27.5	100.0	136.3	16	$6.00	101.0
	(b) Central group.....	11	$2.41	$2.77	$3.75	$6.38	14.9	56.4	164.7	10	$4.53	88.0
	(c) Southern group.....	12	$1.92	$2.01	$3.03	$4.02	4.7	57.8	109.4	10	$3.89	102.0
	(d) Western group.....	5	$3.97	$4.37	$6.31	$7.89	10.1	58.9	98.7	6	$7.92	99.0
	(e) Average of groups (4).....	—	$2.82	$3.24	$4.77	$6.33	14.9	69.2	124.4	4	$5.57	97.0
	(f) Average of all.....	41	$2.62	$3.04	$4.52	$5.69	15.3	73.7	117.1	42	$5.42	107.0
7	Fuel oil, cents per gallon south.....	1	1.80¢	1.80¢	2.00¢	4.50¢	0.0	11.1	150.0	1	4.28¢	138.0
	Fuel oil, cents per gallon west.....	1	1.38¢	1.50¢	2.57¢	3.55¢	8.7	86.2	157.3	4	4.05¢	193.0
8	Alum, cents per pound											
	(a) Western group.....	2	1.14¢	1.21¢	1.51¢		6.1	41.4		3	1.53¢	34.0
	(b) Central group.....	5	0.91¢	0.91¢	1.25¢		0.0	37.0		6	1.50¢	65.0
	(c) Eastern group.....	9	1.12¢	1.72¢	1.48¢		54.0	32.7		8	1.45¢	29.0
	(d) Southern group.....	9	1.08¢	1.38¢	1.48¢		28.0	37.0		9	1.78¢	65.0
	(e) Average of groups (4).....	—	1.06¢	1.30¢	1.43¢		23.3	35.1		4	1.56¢	47.0
	(f) Average of all.....	25	1.07¢	1.40¢	1.44¢		30.6	34.4		27	1.59¢	49.0
	(g) New York market price†.....	Aver. of monthly prices	2.08¢	4.63¢	3.57¢	5 mos. 3.15	123.0	71.6	51.4			

* It was generally reported that there has been also a marked decrease in efficiency of labor since the year 1914, variously estimated at between 20 per cent and 50 per cent; and that the increase in wages paid to labor by water works had not kept pace with contract prices, owing probably to the advantage of continuity of service.

† See *Journal of Industrial and Engineering Chemistry*. Note that 1915 price was an advance of 34 per cent over the 1914 average price before the advances listed went into effect.

TABLE 2

Labor prices paid by water works in the vicinity of Boston, April, 1919

PLACE	COMMON LABOR		PIPE LAYERS AND CALKERS		HOURS PER WEEK	HOLIDAYS §	VACATION 2 WEEKS PAID
	Per day	Per hour	Per day	Per hour			
1. Boston	$3.00	$0.41	$3.25–3.50	$0.444–0.478	44	Not paid	Yes
2. Somerville	3.25	0.443	3.35	0.456	44	Not paid	Yes
3. Newton	3.25	0.443	3.50	0.477	44	Not paid	No
4. Lexington	3.25	0.406	3.50	0.437	48	Not paid	No
5. Waltham	3.25	0.443	3.50–4.50	0.477–0.613	44	Not paid	Yes
6. Everett*	3.75	0.511	4.25–4.50	0.579–0.613	44	Paid	Yes
7. Malden	3.50	0.477	4.00	0.543	44	½ time	Yes
8. Chelsea	3.25	0.406	3.75	0.468	48	Paid	Yes
9. Quincy†	4.00	0.543	4.50	0.613	44	Paid	Yes
10. Medford	3.50	0.477	3.75	0.511	44	Paid	Yes
11. Melrose	3.50	0.477	4.00	0.543	44	Paid	Yes
12. Revere	3.50	0.477	3.75	0.511	44	Paid	Yes
13. Watertown‡	3.50	0.477	3.75	0.511	44		
14. Arlington	3.75	0.511	4.25	0.579	44	6 out of 10	Yes
15. Milton	3.50	0.477	3.93	0.535	44	Paid	Yes
16. Winthrop	3.50	0.437	3.75	0.468	48	Paid	Yes
17. Cambridge	3.50	0.477	3.75–4.00	0.511–0.543	44	Paid	Yes
18. Brookline	3.50	0.477	4.17	0.568	44	Paid	Yes
19. Marlboro	3.50	0.437	3.75	0.468	48	Not paid	No
20. Hudson	3.50	0.437	3.75	0.468	48	Not paid	No
21. Fitchburg	3.36	(0.42)			48	Not paid	Yes
	3.60	0.45					
	3.92	(0.49)					
Average		46.1					

* In Highway Department $3.50 or 47.7 cents per hour.

† High account government activities.

‡ Fifty cent bonus per day for those who work one year.

§ Sixteen allow 2 weeks vacation; eleven pay for holidays; fifteen allow Saturday half holiday under full pay.

1915, they increased one-eighth in 1916, one-fourth in 1917, and nearly three-fourths in 1918. It is interesting to note further that the increase was felt most markedly in the south and upon the eastern seaboard, being nearly doubled in the first, and increased by three-fourths in the latter district.

The wages paid upon the Pacific Coast before the war, which were much higher, have advanced relatively less than elsewhere, so that at the present time the eastern and western unskilled labor prices are about the same. Thus the average rate in the western group increased from 27 cents per hour in 1915 to 42 cents in 1918; while the Southern rate increased from 18 cents to 34 cents; the Central group from 22 cents to 37 cents; and the Eastern group from 23 cents to 40 cents.

It is important to note further that even these rates are probably below current comparable rates for other labor.

Recent data upon labor prices of April, 1919, paid by water works in the vicinity of Boston. It is interesting to note that in spite of the general business uncertainty and resulting depression, wages paid to unskilled labor, by water works in the vicinity of Boston, have advanced from approximately 41 cents per hour, as reported by the author on September 14, 1918, to approximately 46 cents per hour in April 1919, without allowance for the effect of vacations and holidays under pay, granted by some works, as shown by table 2 and present (June 1919) conditions give little if any indication of reduction in prices this year, or hope for any marked reduction in the future.

Cast iron pipe prices, which had about trebled at their maximum point, have now receded to about twice pre-war figures.

Valves, hydrants and pumps, which had more than doubled in price, are now to be had at an advance of something over seven-eighths of pre-war prices.

Coal and fuel oil prices, which more than doubled, have receded somewhat.

Chemicals used in the purification of water, which, by reason of outstanding contracts showed an average advance of but one-third, though the market price had increased approximately three-fourths, have decreased so that the present excess cost is about one-half over pre-war prices.

Future prices. Engineers prefer the rôle of interpreter of facts, to that of prophet of the future.

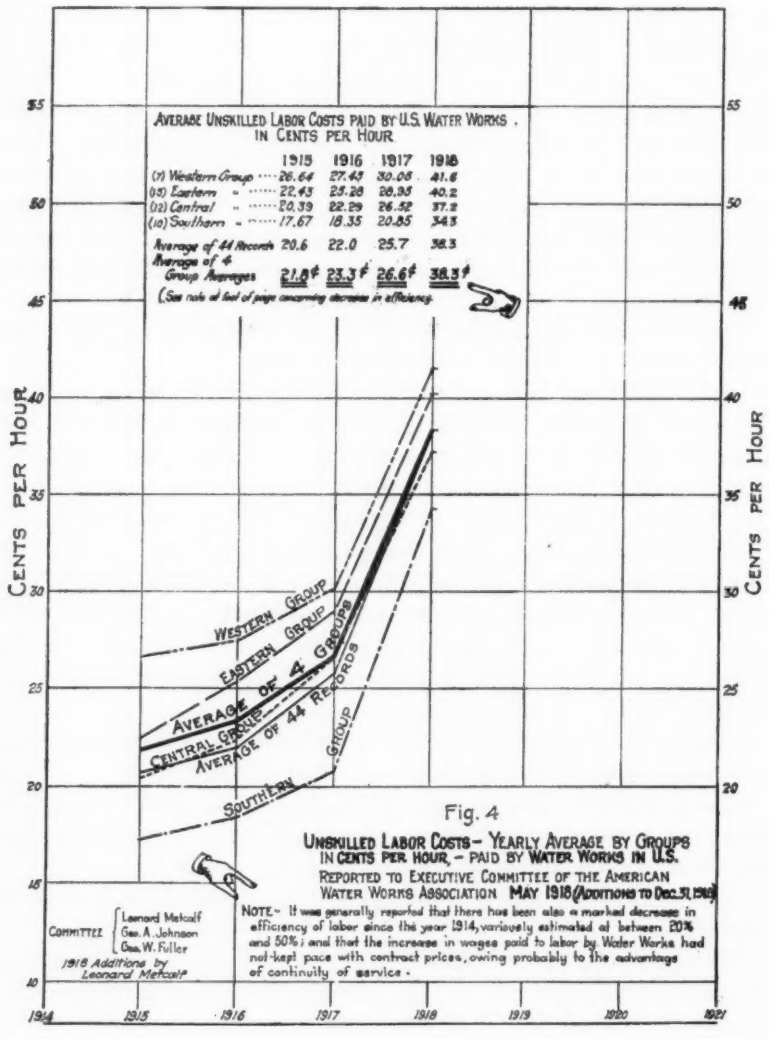
AVERAGE UNSKILLED LABOR COSTS PAID BY U.S. WATER WORKS. IN CENTS PER HOUR.
1915 1916 1917 1918
(7) Western Group 26.64 27.45 30.06 41.6
(15) Eastern " 22.43 25.26 28.95 40.2
(12) Central " 20.39 22.29 26.52 37.2
(10) Southern " 17.67 18.35 20.85 34.3
Average of 44 Records 20.6 22.0 25.7 38.3
Average of 4 Group Averages 21.8¢ 23.3¢ 26.6¢ 38.3¢
(See note at foot of page concerning decrease in efficiency.
CENTS PER HOUR
WESTERN GROUP
EASTERN GROUP
AVERAGE OF 4 GROUPS
CENTRAL GROUP
AVERAGE OF 44 RECORDS
SOUTHERN GROUP
55
50
45
40
35
30
25
20
15
10
1914
1915
1916
1917
1918
1919
1920
1921
COMMITTEE
Leonard Metcalf
Geo. A. Johnson
Geo. W. Fuller
1918 Additions by Leonard Metcalf
NOTE:- It was generally reported that there has been also a marked decrease in efficiency of labor since the year 1914, variously estimated at between 20% and 50%; and that the increase in wages paid to labor by Water Works had not kept pace with contract prices, owing probably to the advantage of continuity of service.

Fig. 4

UNSKILLED LABOR COSTS – YEARLY AVERAGE BY GROUPS IN CENTS PER HOUR, – PAID BY WATER WORKS IN U.S.
REPORTED TO EXECUTIVE COMMITTEE OF THE AMERICAN WATER WORKS ASSOCIATION MAY 1918 (ADDITIONS TO DEC. 31, 1918)

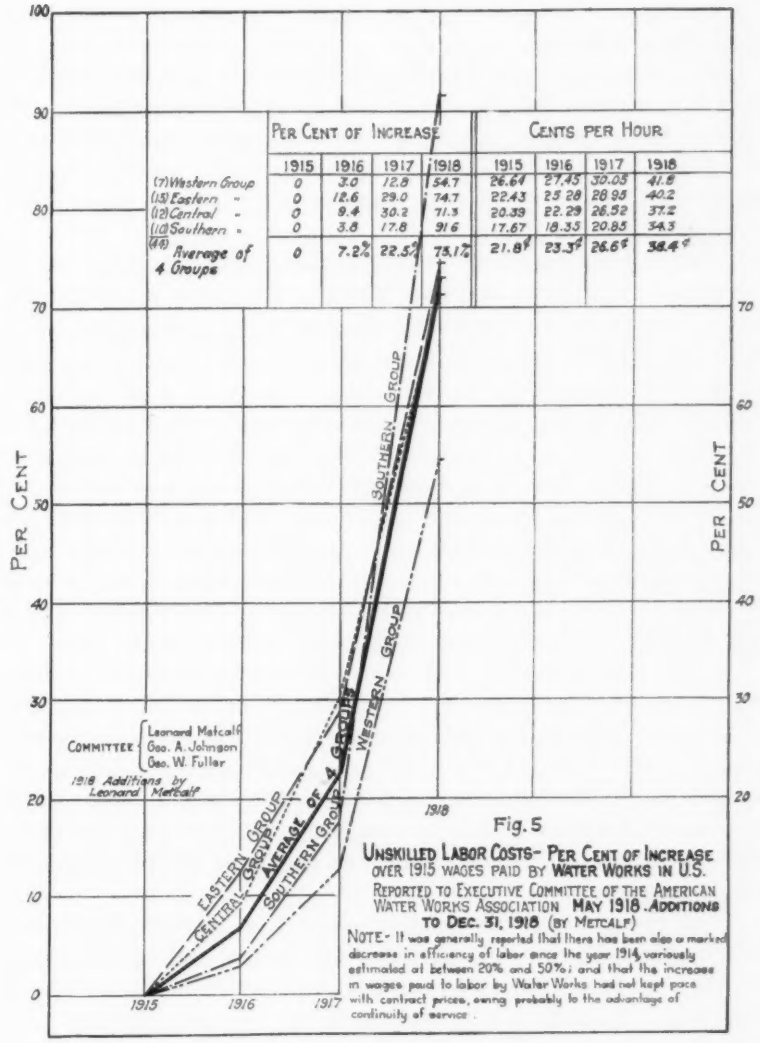
PER CENT OF INCREASE
CENTS PER HOUR
1915 1916 1917 1918 1915 1916 1917 1918
(7) Western Group 0 3.0 12.8 54.7 26.64 27.45 30.05 41.8
(15) Eastern " 0 12.6 29.0 74.7 22.43 25.28 28.95 40.2
(12) Central " 0 9.4 30.2 71.3 20.39 22.29 26.52 37.2
(10) Southern " 0 3.8 17.8 91.6 17.67 18.35 20.85 34.3
(44) Average of 4 Groups 0 7.2% 22.5% 75.1% 21.8¢ 23.3¢ 26.6¢ 38.4¢
PER CENT
SOUTHERN GROUP
WESTERN GROUP
AVERAGE OF 4 GROUPS
EASTERN GROUP
CENTRAL GROUP
COMMITTEE Leonard Metcalf, Geo. A. Johnson, Geo. W. Fuller
1918 Additions by Leonard Metcalf
1915
1916
1917
1918

Fig. 5

UNSKILLED LABOR COSTS- PER CENT OF INCREASE OVER 1915 WAGES PAID BY WATER WORKS IN U.S.

REPORTED TO EXECUTIVE COMMITTEE OF THE AMERICAN WATER WORKS ASSOCIATION MAY 1918. ADDITIONS TO DEC. 31, 1918 (BY METCALF)

NOTE- It was generally reported that there has been also a marked decrease in efficiency of labor since the year 1914, variously estimated at between 20% and 50%; and that the increase in wages paid to labor by Water Works had not kept pace with contract prices, owing probably to the advantage of continuity of service.

It is desirable, however, to note here probable future price tendencies and it is to be hoped that there may be general discussion upon this subject, to the end that members of this society may have the benefit of comparing views and may thus be able to plan more wisely for the future.

First, with respect to unskilled labor—while it is possible that there may be some reduction in its cost during the coming season, no marked change is to be looked for; and with respect to the rates paid to water works employees, it is believed that the prices now paid are likely to continue in most cases, and to increase rather than decrease in the remaining cases.

Unless Bolshevism runs its course in this country, or industrial depression should follow the war—neither of which seem likely—an active demand for labor is to be looked for in the near future. It is to be remembered that despite the war, the population of this country has been increasing at a rapid rate. Immigration has been at a standstill and in the light of home demand for labor abroad does not seem likely to be active for some time to come. Many employers, contractors and labor leaders believe that in the not distant future this country is sure to feel the competition for available labor and that this will stimulate yet higher wage scales. Past experience following wars indicates that later on reaction may come, and business depression be felt for a time, but such influence is not likely to be of long duration or to affect permanently the upward tendencies.

Second, with respect to materials of construction, there is greater hope for relief. Nevertheless, no substantial reduction in the price of cast iron pipe, valves and hydrants seems likely for the present year, and but a gradual reduction is to be looked for in the future. In spite of the increased facilities for production, the labor, transportation and money conditions involved seem likely to make themselves adversely felt for some time, and the losses resulting from the war, permanently.

Third, the materials of operation—coal, fuel oil, and chemicals—do not appear likely to decline markedly in cost, and such tendency toward decrease as there may be, will probably cause the making of short-time, rather than long-time, contracts for such supplies.

Declining service. Capital has not been available for many desirable extensions during the war period. The added financial burden of such new construction as has had to be undertaken, has in many cases been substantial. The increase in operating costs and taxes has been tremendous.

The structural plants of water works properties have not been maintained generally in normal condition during the war. Such has been the experience abroad, as well as in the United States. The obtaining of needed added supplies, drainage areas and water rights, the enlargement of the mechanical, pumping and boiler plants, the extension and reinforcement of supply and distribution pipe systems, and the making of normal betterments of various kinds, have been deferred, in order to conserve the country's financial resources, for war purposes.

It will probably be admitted generally, by water works men, that *the war has enforced upon water works, as upon other public utilities, a declining service.*

The future. The conclusion to be drawn from the present physical and financial condition of water works in the United States seems clearly to be that *necessary improvements should go forward as rapidly as possible.* It is desirable to restore public confidence and further the government's wise wish to give employment to idle labor. More important yet, *improvements are seriously needed to restore our normal high standard of water service, to adequately safeguard the public health.*

While city officials and water works men are hesitating, the large manufacturing interests dominated by shrewd, far-sighted business men, are going ahead with their construction work, with their plant extensions and housing projects, confident that postponement will at best offset increased cost in small measure; will probably involve loss in service or profit far exceeding any saving in construction cost; and at worst will involve yet higher costs, coupled with these losses and with increasing difficulties due to a vanishing labor surplus.

The public is far more vitally interested in thoroughly good and adequate present service, than in any probable saving to be effected by delaying construction to a later date, in anticipation of further, more or less problematical decline in costs.

THE CHLORAMINE PROCESS AS APPLIED TO THE CATSKILL (ESOPUS) WATER[1]

By Dr. Frank E. Hale

On August 1, 1917, the control and maintenance of the new Catskill system of water supply for New York City, with the exception of unfinished work, was turned over by the Board of Water Supply to the Department of Water Supply, Gas and Electricity. As at certain points untreated sewage finds its way into Esopus Creek or its tributaries above Phoenicia, it was at once determined to immediately install a temporary chlorination plant below Phoenicia and to operate this plant so long as the direct pollution of the stream should exist. For various reasons, economical and otherwise, peculiar to this particular problem, it was decided to employ bleach.

A long building was erected on the bank of the Esopus, so arranged that the drums of chemical are discharged directly from the truck to the storeroom on the upper floor of the building, where they are on a level with the tops of the tanks. There are five tanks of 3500 gallons capacity. The solution feed is through weir boxes to a pipe stretching diagonally across the stream, perforated with holes and weighted down by heavy stones in order to withstand heavy freshets. A well was dug near the creek and connected by pipe with the creek water. A float in this well gauges the height of the water in the stream and serves as a source of water supply for the plant, water from this well being pumped by a small gasoline pump to the tanks.

The plant was completed and in operation by the middle of October. Because of previous experience with chlorination of the City's water supply, treatment was started with 0.4 p.p.m. available chlorine. Immediately complaint was received from the Conservation Commission at Albany that dead trout and other fish to the number of over 800 had been discovered by the local forest ranger within 2 miles of the plant. The largest trout shown measured 21½ inches. Kingston, New York and Brooklyn newspapers took up the cudgels with preposterous and exaggerated statements under

[1] Read before the New York Section on February 19, 1919.

headings such as "Ton of Trout Dead in Esopus Creek," "Wasting Food," etc.

Search of the literature failed to reveal any extensive amount of information upon the subject. The author was unfamiliar with any similar occurrence since the introduction of modern treatment of water supplies with chlorine compounds. Inquiries sent to Denver, Colo., and Ottawa, Canada, failed to reveal any similar experiences. A few trout had been killed on one Croton watershed stream by a dosage of 1 p.p.m. when chlorination was begun, but such an occurrence has not been noticed since.

Schwartz and Nachtigall of the State Hygienic Institute of Hamburg, Dr. Dunbar, Director, experimented with eels, gold fish, and perch. These were found not to be affected by 1 p.p.m. available chlorine (bleach) at 15 to 18°C. in six days time. The same results were obtained up to 1.6 p.p.m. chlorine. With 2.5 p.p.m. chlorine the fish died on the second day. Mason states in his book *Water Supply*, fourth edition, page 270, on authority of Weigelt, published in *Das Wasser* by Fischer, page 52, that 0.5 p.p.m. chloride of lime (0.17 p.p.m. chlorine) killed trout in three hours.

Trout are, of course, very susceptible fish and are stated in *Microscopy of Water Supply*, Whipple, to be killed by 0.14 p.p.m. copper sulphate.

Change of environment will kill certain fish. When Catskill water was first introduced in New York City complaints were received both from Manhattan and from Brooklyn that gold fish were killed, and gold fish are not as susceptible as trout. Such complaints are no longer received.

A conference was held at the plant on November 26, 1917, with A. S. Houghton, secretary to the Conservation Commission, accompanied by Llewellyn Legge, chief, Division of Fish and Game, and J. W. Titcomb, state fish culturist. Later direct communication was held with Commissioner George D. Pratt of the Conservation Commission. The Water Department officials could not take the responsibility of stopping chlorination but assured the members of the Commission that close control of the plant would be maintained and every endeavor made to lessen the amount of chemicals added to the stream and to prevent so far as practicable bleach sludge from entering the stream, since trout are susceptible to solid particles, such as sawdust or lime hydrate.

In addition, investigation was started of the chloramine process.

developed by Joseph Race, with the idea of still further reducing the chemicals used, and a trip was made to Ottawa on December 5, 1917, where he was engaged as city bacteriologist and chemist. Decision was made to try out the process.

It may be stated at this point that other fish than trout were killed, particularly suckers, that the Commission experimented with fish in cages, which flourished above the plant and died below. The fish continued to die at intervals during the fall, during which time the chlorine was reduced to 0.2 p.p.m. Since that winter there has been no further trouble.

The chloramine process consists in combining bleach with ammonia just before applying it to the water to be treated. The reaction is very simple, the two combining to form ammonium hypochlorite and lime hydrate. The former is unstable and undergoes intermolecular change, losing water and forming chloramine. The reaction is as follows:

$$\underset{\text{Bleach}}{2\,CaOCl_2} + \underset{\text{Ammonia}}{2\,NH_4OH} = \underset{\text{Chloramine}}{2\,NH_2Cl} + 2\,H_2O + CaCl_2 + CaO_2H_2$$

In this theoretical action the ratio by weight of ammonia to chlorine is 1:4.

The chemicals must be in very dilute solution to react correctly. The department used a 2.5 per cent solution of bleach, 0.875 per cent available chlorine, on a 35 per cent basis, and a 0.22 per cent solution of ammonia, NH_3. The formation of chloramine is indicated by a much stronger free chlorine test in the water treated, either by orthotolidin or by starch-iodine reaction, than with bleach alone.

Other reactions may be written with different ratios of ammonia to chlorine, but judging from the department's experience, are incorrect to use. For example, the ratio NH_3: Cl: : 1 : 2 as follows:

$$CaOCl_2 + 2\,NH_4OH = \underset{\text{Chloramine}}{NH_2Cl} + H_2O + NH_4Cl + CaO_2H_2$$

This reaction has been used at Denver, Colorado, and would naturally be the first to be considered, but it actually wastes one-half the ammonia in forming ammonium chloride, and as ammonia costs four times as much as bleach the amount of ammonia becomes a very important item.

Again certain laboratory experiments by Race indicated equal bacterial efficiency for a ratio of NH_3: Cl: : 1: 8. As it seemed possible that such a ratio might indicate the formation of a dichloramine, it was tried, but the department's results indicate that the reaction products are a mixture of chloramine and bleach. The desired reaction, if it formed dichloramine, would be as follows:

$$2\,CaOCl_2 + NH_4OH = \underline{NHCl_2} + H_2O + CaCl_2 + CaO_2H_2$$

Dichloramine
(Unknown)

With excess ammonia and particularly with strong solutions the reactions take other directions, as mentioned by Race, with the formation of nitrogen gas and ammonium chloride as follows:

$$3\,NH_2Cl + 2\,NH_3 = \underline{N_2} + \underline{3\,NH_4Cl}$$

Nitrogen Ammonium chloride

or hydrazine hydrochloride thus:

$$NH_2Cl + NH_3 = \underline{N_2H_4 \cdot HCl}$$

Hydrazine hydrochloride

During warm weather the author made a few analyses of the original solutions of ammonia and of bleach as compared with the liquid just after mixing and found a loss of available chlorine of about 20 per cent. This was probably due to reactions such as the above.

With excess of chlorine the reactions will not go as above but form nitrogen gas or nitrogen trichloride, a very explosive oil. The latter reaction may be simply written as follows:

$$NH_3 + 3\,Cl_2 = \underline{NCl_3} + 3\,HCl$$

Nitrogen
trichloride

This probably explains the failure, as given by Race, of chlorine gas to react with ammonia to form chloramine. The reaction would seem very simple as follows:

$$NH_3 + Cl_2 = \underline{NH_2Cl} + HCl$$

Chloramine

But the formation of acid apparently must be prevented. The department intended to experiment with chlorination of water with gas and later adding ammonia, but has not as yet tried it out.

The application of the chloramine process at Phoenicia involved merely separating one tank from the others and connecting it to a new weir box. The two solutions were then brought together at once and passed through the pipe into the stream. The reaction forms lime hydrate which clogs the pipe, causing frequent cleaning. This trouble may be diminished, as suggested by Race, by adding additional flush water with the solutions.

The laborers at the plant complained of the effect of fumes on the eyes. They were furnished with goggles to protect the eyes and respirators, with tartaric acid for the sponges, while mixing ammonia. In mixing, a 750-pound drum of ammonia was placed on a 1000-pound platform scale. Several feet of water were pumped into the tank. A special device was made to allow air to enter the drum as the ammonia came out. The ammonia was allowed to flow through a hose to the bottom of the water in the tank until 218 pounds were added. As the ammonia was 26° Bé. or 29.4 per cent NH_3, that made 64 pounds of ammonia gas to the tank. The ammonia was procured from the Barrett Company, New York City, who controlled the product, due to the government requisitioning practically all ammonia. Later permission to purchase was obtained through the ice comptroller.

A drum (approximately 700 pounds) of bleach was added to a tank of water at a time and churned by a paddle containing cross cleats until well mixed, as power was not available.

The plant was under close laboratory control. Analyses were made of each tank of bleach solution at the beginning, middle and end of the run, and similarly of the ammonia solution. The available chlorine was determined by the iodometric method (potassium iodide and acetic acid) and the amount of ammonia by titration with sulphuric acid using azolitmin as indicator. The results were charted each week, as shown in figure 1.

Very little trouble was experienced in making uniform solutions of ammonia, but owing to improper facilities the bleach values showed considerable variation at times. The average theoretical chlorine applied on a 35 per cent basis for the year 1918 was 0.108 p.p.m., whereas corrected for analyses of tank solutions the average chlorine was 0.102 p.p.m. During 75 per cent of the time the

maximum variation was less than ± 30 per cent of the theory. Likewise during 80 per cent of the time the maximum variation of ammonia from the theory was less than ± 20 per cent.

Daily analyses were made of the stream before and after chlorination, the latter samples being taken about one-half mile below the plant. This point was decided upon after a series of results at different distances down to two miles. These samples were analyzed physically, bacteriologically and for free and fixed chlorine.

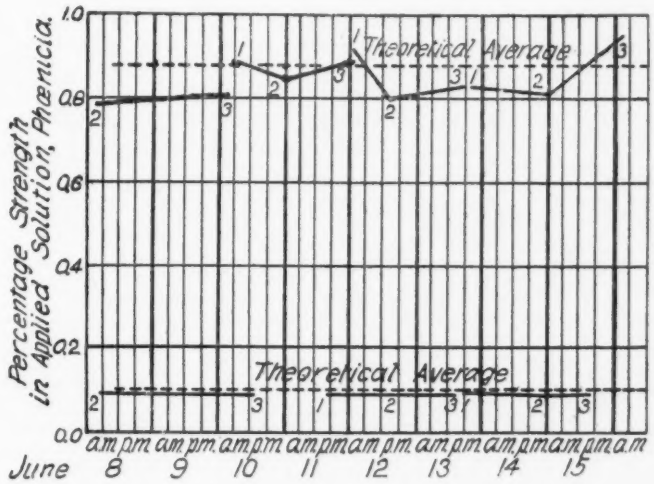
Percentage Strength in Applied Solution, Phœnicia.
1.0
0.8
0.6
0.4
0.2
0.0
Theoretical Average
Theoretical Average
am pm am pm am pm am pm am pm am pm am pm am pm am pm am
June 8 9 10 11 12 13 14 15

FIG. 1. STRENGTH OF CHLORINE (upper part of diagram) AND AMMONIA SOLUTIONS (lower part of diagram) AT THE PHOENICIA PLANT FOR THE PERIOD ENDING JUNE 15, 1918

The broken line giving the theoretical average is based on 35 per cent chlorine in bleach and 29.4 per cent ammonia. The numerals 1, 2 and 3 indicate the values of solutions, samples taken at the beginning, middle and end of a run.

In order to make the last determination as accurate as possible the quantity of water evaporated for analysis was increased to 500 cc. early in February and to 1000 cc. early in June. A chart of all these results indicates a probable error of ± 0.03 p.p.m. with the latter quantity evaporated. The increase in fixed chlorine thus gave a good indication of the amount of chlorine applied to the sample whose bacteriological character was determined. In fact, usually, the free chlorine and bacteriological results varied with the increase in fixed chlorine. Considerable study was made of this

point, since these analytical results varied greatly from the theoretical. It is probable that such differences are explained by variation in the strength of the bleach solution, variation in the feed, variation in the estimated flow of the stream and variation in the admixture of chemical solution with the stream. Results have therefore been averaged both by theoretical chlorine applied and by chlorine as determined by analysis, that is increase in fixed chlorine. The latter seemed to give the more consistent results. Comparison of the increase in fixed chlorine with the theoretical chlorine applied for the year 1918 gives an average of 0.128 p.p.m. against 0.108 p.p.m. Out of three hundred analyses 106 agreed with the theory, 94 were above the theory and 100 were below the theory. There was no definite relationship of these fluctuations with the ratios of ammonia to chlorine, but there was a seasonal relationship probably

TABLE 1

Comparison of analytical with theoretical chlorine applied

	SAMPLES COINCIDING	SAMPLES ABOVE THEORY	SAMPLES BELOW THEORY
Summer	40	30	77
Winter	66	64	23
Total	106	94	100

due to variation in stream flow as evidenced by a low or high absolute amount of chlorides present in the water. Thus in the months April to September there were twice as many analyses below the theory as above and during the months January to March and October to December, the reverse was true. Table 1 illustrates this.

The above matter has been studied in considerable detail since the results obtained by care in the determination of the increase in fixed chlorine by analysis seem to warrant future attention. It is more important than the presence of free chlorine, since bacteriological results appear to be obtained even when no free chlorine is left in the water treated.

During the early part of the work bacteriological samples were sent to Brooklyn, but from June 1 these results were obtained at the new Catskill laboratory. Despite delay in transit of samples, comparison of results obtained at the two laboratories has shown that

many of the Brooklyn results are sufficiently reliable, particularly with regard to B. coli, to be included in the averages. In many cases the relative number of such samples is too small to greatly affect the results.

The results of these determinations were tabulated in the usual way, according to the theoretical dosage and the results obtained at the two laboratories were reasonably comparable. Especially noteworthy was the removal of 93 per cent of B. coli with such a small dosage of chlorine as 0.05 p.p.m. when feeding bleach alone and 0.033 p.p.m. when feeding chloramine, ratio NH_3 : Cl :: 1:4. The results with the 1:8 ratio were decidedly inferior. However, as the theoretical chlorine applied does not always agree with that determined by analysis, greater reliance is placed on the results given in Table 2 in which the results are averaged according to the analytical results of the chlorine applied, i.e., increase in fixed chlorine. This is a better way of showing efficiency, which the author has not seen used before this.

From table 2 the conclusion would seem warranted that the results with ratio of NH_3: Cl: : 1: 8 are inferior to the other results, that the chloramine ratio 1:4, yields no better results than bleach alone. The bacteria and B. coli removal with an application of 0.05 p.p.m. available chlorine bleach compared to chloramine, is, respectively; bacteria, 71 per cent and 74 per cent, and B. coli 98 per cent and 96 per cent. The results are consistent throughout the table.

Figure 2 shows at a glance the results for B. coli removal obtained with various amounts of bleach applied.

It should be explained that in every case in this study the percentage for B. coli removal is based upon the comparison of numbers obtained by multiplying the percentage of positive tests in 0.01 c.c. by 1000, in 0.1 cc. by 100, in 1 cc. by 10 and in 10 cc. by 1 and adding, also on the assumption that all treated water would give a positive test in 100 cc. This assumption, together with the use of decimal places in fractions of a percentage is necessary in order to show differences of efficiency in treatment of waters of varying degrees of pollution.

From table 2 it is also seen that with bleach very little or no chlorine is residual in the water, whereas with chloramine ratio 1:4, the residual free chlorine (determined within a few hours by orthotolidin) increases practically proportionately to the increase in fixed

TABLE 2

Average analyses by chlorine applied, as determined by increase in fixed chlorine

INCREASE IN		RANGE OF TEMPERATURE	NUMBER OF SAMPLES			RAW WATER					TREATED WATER				PER CENT REMOVAL	
							B. coli per cubic centimeter					B. coli per cubic centimeter				
Fixed chlorine	Free chlorine		Catskill	Prospect	Total	Bacteria per cubic centimeter 37°C.	0.01	0.1	1	10	Bacteria per cubic centimeter 37°C.	0.1	1	10	Bacteria	B. coli
Bleach alone																
p.p.m.	*p.p.m.*	°F.				*per cent*	*per cent*	*per cent*	*per cent*	*per cent*		*per cent*	*per cent*	*per cent*		
0.55	0.03		1		1	60	0	0	+	+	0	0	0	0	100	99.0
0.50	0.02			1	1	12		+	+	+	2	0	0	0	83	99.9
0.45	0.01		1		1	160	0	0	+	+	9	0	0	0	94	99.0
0.40	0.01	32–45		5	5	15	0	20	60	60	4	0	0	0	73	99.6
0.35	0.01	32–48	2		2	21	0	0	0	100	1	0	0	0	95	90.0
0.30	0.04	32–48	3	2	5	11	20	80	80	100	2	0	0	0	82	99.97
0.25	0.01	32–59	6		6	16	0	0	83	100	0	0	0	0	100	99.0
0.225	0.01		1		1	4	0	0	+	+	0	0	0	0	100	99.0
0.20	0.01	32–52	8	4	12	20	17	25	58	100	3	0	0	0	85	99.95
0.15	0.01	32–51	13		13	17	15	23	54	100	1	0	0	8	94	99.96
0.125	0.01		2		2	12	0	0	0	100	1	0	0	0	92	90.0
0.10	0.00	32–38	17		17	13	12	12	41	100	2	0	6	29	85	99.3
0.05	0.00	32–51	15		15	34	13	20	53	100	10	0	20	73	71	98.0
0.00	0.00	38–40	2		2	124	0	0	50	100	107	50	100	100	14	0.00
Chloramine, Ratio NH_3: Cl:: 1: 4																
0.40	0.03	57–74	2		2	450	0	50	50	100	69	0	0	50	85	99.0
0.35	0.11	48–60	5		5	68	40	60	80	100	1	0	0	0	99	99.98
0.30	0.08	56–72	11		11	108	18	45	100	100	3	0	0	9	97	99.96
0.25	0.04	38–72	8		8	252	63	63	88	100	13	0	13	38	95	99.8
0.20	0.02	44–77	6		26	211	0	17	50	100	9	0	0	17	96	99.0
0.15	0.05	32–74	19	2	1	152	14	38	71	100	17	0	10	48	89	99.2
0.10	0.03	32–76	29	3	32	104	13	25	69	97	9	3	6	19	91	98.0
0.075			1		1	8	0	0	+	+	0	0	0	0	100	99.0
0.05	0.02	32–74	31	1	32	164	16	28	72	97	42	3	41	88	74	96.0
0.025	0.02		1		1	10	0	0	0	+	3	0	0	+	70	0.0
0.00	0.00	32–70	7	4	11	44		9	55	82	37	9	46	64	21	7.0
Chloramine, Ratio NH_3: Cl:: 1: 8																
0.25	0.01		1		1	32	+	+	+	+	12	0	+	+	62	99.0
0.20	0.03	47–54	6		6	29	0	0	50	83	1	0	0	0	97	98.0
0.15	0.02	46–51	5		5	23	0	0	60	100	2	0	0	40	91	94.0
0.10	0.02	45–58	2	1	3	107	0	33	100	100	67	0	67	100	47	83.0
0.05	0.01	41–59	1	1	2	31	0	0	50	100	11	0	50	50	65	8.0

chlorine, that is, chlorine applied. With ratio 1:8 the increase in free chlorine is approximately one-half that obtained with ratio 1:4. These free chlorine results indicate the actual formation of chloramine in these treatments when ammonia was applied and also

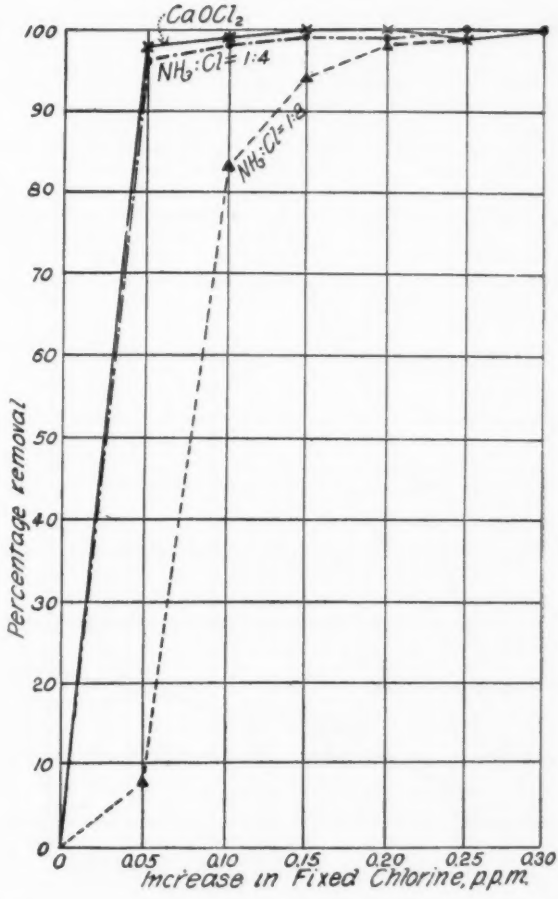

FIG. 2. COMPARISON OF EFFICIENCY OF CHLORAMINE WITH BLEACH IN B. COLI REMOVAL FROM ESOPUS CREEK WATER

indicate that with the ratio 1:8 the result was a mixture of chloramine and bleach. These facts are shown clearly in figure 3.

The query has frequently been raised as to difference of efficiency of chlorination in winter and in summer. In table 3 are grouped the

detailed results obtained with application of 0.10 p.p.m. chloramine, ratio 1:4, throughout the year.

Table 3 is extremely interesting. The amount of residual free chlorine is the same for all temperatures, an average of 0.03 p.p.m;

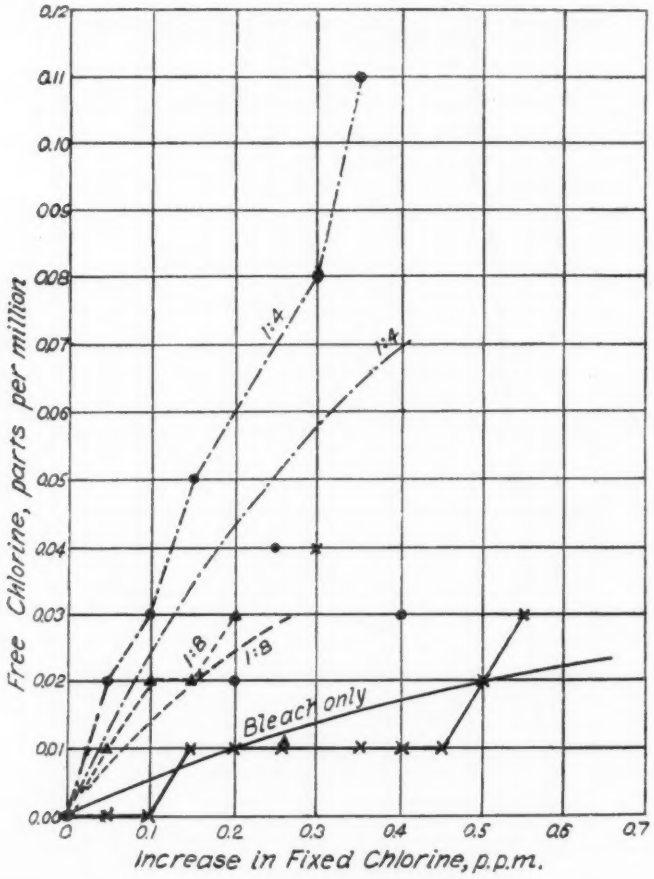

FIG. 3. RELATION OF FREE CHLORINE TO FIXED CHLORINE FOR THE VARIOUS RATIOS OF AMMONIA TO CHLORINE GIVEN ON THE CURVES

in fact 16 results out of 29 tests are 0.03 p.p.m. Likewise the percentage bacterial and B. coli removal is similar at all temperatures. The conclusion is inevitable that the actual work performed is the same no matter what the temperature. It is also obvious,

TABLE 3

Relation of temperature to chloramine efficiency. Application of 0.10 p.p.m. available chlorine, ratio NH_3: Cl:: 1 : 4, as determined by increase in fixed chlorine

TEMPERATURE	FREE CHLORINE	RAW WATER					TREATED WATER				PER CENT REMOVAL	
		Bacteria per cubic centimeter 37°C.	B. coli				Bacteria per cubic centimeter 37°C.	B. coli			Bacteria	B. coli
			0.01	0.1	1	10 cc.		0.1	1	10 cc.		
°F.	p.p.m.											
32*	0.04	2	0	0	0	+	0	0	0	0	100	90.0
32*	0.02	26	0	0	+	+	9	0	0	0	65	99.0
41*	0.00	6	0	0	0	0	4	0	0	0	33	
60	0.04	180		+	+	+	3	0	0	+	98	99.0
64	0.04	100	0	0	+	+	3	0	0	+	97	90.0
63	0.03	230	0	0	+	+	28	0	+	+	88	0.0
59	0.03	140	0	0	0	+	0	0	0	0	100	90.0
65	0.03	150	0	0	+	+	19	0	0	0	87	99.0
63	0.03	120	0	0	0	+	11	0	0	+	91	0.0
65	0.03	50	0	0	+	+	3	0	0	+	94	90.0
71	0.03	430	+	+	+	+	46	0	0	+	89	99.9
64	0.01	500	+	+	+	+	55	0	+	+	89	99.0
68	0.02	250	0	0	+	+	19	0	+	+	92	0.0
68	0.03	240	+	+	+	+	22	0	+	+	91	99.0
72	0.03	200	+	+	+	+	19	0	0	+	90	99.9
68	0.03	140	0	0	0	+	6	0	0	0	96	90.0
76	0.03	29	0	0	+	+	8	0	0	+	72	90.0
69	0.03	120	0	+	+	+	5	0	0	+	96	99.0
68	0.02	130	0	+	+	+	8	0	0	0	94	99.9
46	0.03	21	0	0	+	+	9	0	0	0	57	99.0
40	0.03	14	0	0	0	+	0	0	0	0	100	90.0
42	0.02	27	0	0	0	+	4	0	0	+	85	0.0
41	0.03	9	0	0	0	+	0	0	0	0	100	90.0
42	0.06	24	0	0	+	+	0	0	0	0	100	99.0
44		27	0	0	0	+	1	0	0	+	96	0.0
45		12	0	0	0	+	0	0	0	0	100	90.0
48	0.04	42	0	0	+	+	0	0	0	0	100	99.0
45	0.03	33	0	0	+	+	0	0	0	0	100	99.0
32	0.03	23	0	+	+	+	2	+	+	+	91	0.0
32	0.02	31	0	0	0	+	6	0	0	+	81	0.0
36	0.02	35	0	0	+	+	9	0	0	0	74	99.0
Ave. 53	0.03	104	13%	25%	69%	97%	9	3%	6%	19%	91	98

(32–76° range.)

* Analyzed at Mt. Prospect Laboratory. Samples conveyed by messenger.

however, that B. coli is present in certain quantities in the treated water in the summer periods, but this is due to the fact that pollution is greater in the untreated water in the same period. To remove this B. coli would require the application of a greater dose of chlorine, but only because the raw water was worse and contained more B. coli and not because of any temperature differences. It may also be true that if at any time of year the water should be more highly colored, more turbid, or contain more organic matter

TABLE 4

Treatment of turbid water with chloramine

TURBIDITY	LABORATORY	AVAILABLE CHLORINE APPLIED			TEMPERATURE	RAW WATER					TREATED WATER				REMOVAL	
		Ratio. NH_2:Cl	Theory	Analytical		Bacteria per cubic centimeter	B. coli per cubic centimeter				Bacteria per cubic centimeter	B. coli per cubic centimeter			Bacteria	B. coli
						37°C.	0.01	0.1	1	10	37°C.	0.1	1	10		
p.p.m.			*p.p.m.*	*p.p.m.*	°*F.*										*per cent*	*per cent*
6	Cat.	1:4	0.15	0.15	58	300	+	+	+	+	9	0	+	+	97	99
8	Cat.	1:4	0.15	0.25	72	300	+	+	+	+	45	0	+	+	85	99
8	Cat.	1:4	0.15	0.05	71	560	+	+	+	+	7	0	+	+	99	99
10	Cat.	1:4	0.15	0.40	57	230	0	0	0	+	2	0	0	0	99	90
12	Pros.*	1:8	0.05		41	4	0	0	0	+	0	0	0	0	100	90
14	Cat.	1:4	0.05	0.20	48	85	0	0	+	+	3	0	0	0	96	99
18	Cat.	1:4	0.10	0.05	40	38	0	0	+	+	6	0	0	+	84	90
25	Cat.	1:8	0.15		55	380	+	+	+	+	15	0	0	+	96	99.9
30	Pros.*	1:4	0.07	0.07	32	58	0	0	+	+	20	0	0	0	66	99
100	Pros.*	1:4	0.03	0.05	34	275	0	+	+	+	120	0	+	+	56	90

* Several days in transit.

more chlorine might be required, but temperature would not appear to be the reason.

Similar results are obtained if we tabulate the results with bleach alone, but there is no necessity for unduly burdening this paper with tables.

It so happens that on several occasions, while treating with chloramine, the water was turbid, as Esopus creek is apt to be. Usually the turbidity was low, only 2 or 3 p.p.m., and unfortunately such

occasions did not occur during the use of bleach alone. As chloramine is stated to be less affected by turbidity, the results for chloramine are shown in Table 4, which may prove useful in studies of the treatment of waters which tend to run turbid.

It may be said in closing that the results for 16 months up to and including February 1, 1919, have been included in this study, and that not until the final averages, obtained within a week, did it appear that the chloramine gave no greater efficiency than bleach alone. That such excellent results were obtained with such small doses of chlorine was a complete surprise to the author and can only be explained by the character of the water treated, which is practically free from organic matter, extremely low in mineral content and usually colorless and free from turbidity in the absence of storms. During storms the water is very muddy and the flow is beyond the capacity of the plant to treat.

It is the author's pleasure to express at this time his appreciation of the splendid cooperation of the engineering staff, particularly R. N. Wheeler, division engineer, and W. D. Hubbard, assistant engineer, of the Catskill watershed, without whose able assistance this work could not have been carried through with sufficient finesse. A word of appreciation is also due A. E. Corneau, laboratory assistant in charge of the Catskill laboratory, for his interest and care in performance of the necessary chemical and bacteriological work.

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DISCUSSION

MR. WIGLEY: The author has given interesting data concerning the chloramine treatment of water supplies, for which we are greatly indebted to him. However, there are certain features of this method of treatment which it appears require further explanation. Relative to the destruction of fish, the speaker had occasion to investigate this matter sometime ago and learned from some experiments made by the Massachusetts State Board of Health that it was noted that alkalies were much more injurious to the fish than were dilute acids, the alkalies in the water affecting the gills of the fish, covering them with slime, and causing death by suffocation. With acid waters the fish had the power of correcting the acidity to a certain extent and making the water alkaline. In the work at Esopus could it be decided whether it was the chlorine in the bleach or the alkali which killed the fish?

DR. HALE: It was not the chlorine, probably, but the alkaline sludge which necessarily reaches the water to some extent because of the necessity of thorough mixing of the bleach in the tanks.

MR. WIGLEY: From experience with the condition of streams in New Jersey, it would appear that the water in the stream mentioned by the author was an unusually good quality surface water, as a satisfactory reduction of bacteria was obtained with doses of from 0.1 to 0.2 part of available chlorine. In New Jersey such a stream as this would be of rare occurrence, as the ordinary turbidity and color would necessitate a dose of from one to two parts per million for satisfactory reduction of the bacteria. It is only on waters that have been previously filtered that a dose of 0.1 or 0.2 part would prove satisfactory. From the tables given by the author, it would appear that the chlorine in the bleach used in the same quantity as the available chlorine used in the chloramine combination gave just as satisfactory results, clearly indicating that the increased cost of the chloramine process was not justified. The author's statement relative to the saving in the cost of chemicals is not quite clear, unless possibly this saving was due to the difference between the estimated 0.4 part per million of chlorine required and which in actual practice was reduced to 0.1 part per million when actually in operation.

DR. HALE: The author did not intend to imply that there was a saving by the use of chloramine. The saving would have resulted by the use of bleach alone.

MR. WIGLEY: It appears that the objections to the use of chloramine, mentioned in the paper, condemn it for consideration as a practical means of sterilizing water supplies. Among the objectionable features mentioned in this paper are the very careful chemical control required for mixing the two chemicals, bleach and ammonia, the effect upon the eyes of the workmen, and the fact that at small plants only parts of a drum of hypochlorite could be used, resulting in the loss of available chlorine, and, in the absence of careful chemical control, the uncertainty of the strength of the mixture. There is also mentioned the fact that the actual amounts of chlorine applied varied from 30 per cent below to 30 per cent above the theoretical amount which was being added even with most careful laboratory control. There is also still present the problem of getting rid of the sludge, which has always been an objectionable feature of the hypochlorite method of treatment.

MR. ACKERMAN: About four or five years ago, in Auburn, New York, the water board put in a hypochlorite plant and used it until it put in chlorine gas. This was not used continuously and during certain portions of the year it was out of use. As the board was buying hypochlorite of lime in large drums, it very frequently happened that it would have some left over, and on cleaning up the plant after use, there was about one-half drum of hypochlorite of lime left. As it would be some time before this would be used and hence the chlorine content would be unknown without an analysis, which the board had no facilities to determine, the speaker ordered a workman to dispose of it, giving him explicit instructions where to dump it. But he misunderstood, and as the pumping station is out in Owasco Lake and the outlet of the lake runs alongside the station, it being an artificially dredged channel, with a flow of about 300 cubic feet per second, the channel being something over 1000 feet in length, he dumped probably 300 or 400 pounds of hypochlorite into this outlet. Inside of one-half hour, the speaker received a telephone message that the surface of the outlet was covered with dead fish. The peculiar thing was that it seemed to kill the small suckers from six to eight inches long. Possibly the

larger fish were not in this channel. These suckers were ruptured and their bladders were sticking out.

MR. BOWLES: The speaker has had two different experiences in the killing of fish. Some years ago in Panama, before liquid chlorine was installed, they used bleach, and a drain from the bleaching tank emptied into a small volume of water containing a rather large number of fish, mostly small ones. Quite a number of these fish were killed and upon examining them the same conditions were found as described by Mr. Ackerman, which led to the belief that the sludge had affected their gills.

It seems to the speaker, from what he could always notice, that copper sulphate when put into a reservoir, acts as a sort of mechanical attraction to fish, as they will follow after the bag when it is being pulled through the water and suck the strong solution. This is quite true of the smaller fish. Further out in the reservoir, where they do not come in immediate contact with the stronger solution, there is practically no trouble from killing fish. Last year in one of the reservoirs in Oklahoma, there was some trouble from the killing of fish after using copper sulphate, but this was caused by the copper sulphate not being put in accurately.

Another instance in regard to fish killing. A few years ago the speaker's firm was retained to make an investigation for a sportsmen's club as to the cause of the loss of a great many trout. Bleach was used for disinfecting purposes in the stream, and again trouble was noticed with sludge from the bleach. Trout are very delicate fish to handle. If liquid chlorine had been used at that time, it is unlikely there would have been any trouble in cleaning up the hatcheries. It appears that the sludge from bleach affects the fish and the speaker has not noticed this when gas is used.

MR. ORCHARD: In Mr. Race's paper, presented in 1917, it was brought out in the discussions that chlorine as applied in pure form could not be used in the formation of chloramine. At that time, the value of chlorine was a little high. A year ago Mr. Race was inclined to believe that chloramine could be formed by applying a little ammonia and a little chlorine together. Have the New York investigations shown that this could be done?

DR. HALE: The author intended to go into this but has not. He had the idea that by putting chlorine gas into the water first and letting it react with the alkalinity of the water there would be formed calcium hypochlorite in the water, and that by adding ammonia a little later chloramine might possibly be produced. However, local concentration of ammonia is liable to produce other reactions.

Accurate control is necessary when the chloramine process is applied to the treatment of small water works. And if chloramine is no more active than chlorine alone it would cost twice as much. The form the reaction takes seems to depend upon the proportion of chemicals, the strength of solutions, and the acidity or alkalinity.

The original amount of chlorine used was 0.4 p.p.m. This was reduced to an average of 0.1 p.p.m. The author did not mention cost in the paper since the chloramine proved to be no more efficient than the bleach per unit of available chlorine. The ammonia cost four times as much as the bleach, so that for a ratio of 1: 4, ammonia to chlorine, the chemicals for the chloramine process cost twice as much as bleach alone for an equal dosage of available chlorine. There is then the disadvantage of handling two solutions instead of one.

There was appropriated for 1918, $33,790 for chemicals for the Phoenicia plant and the actual value of chemicals used was $2,911 (including the ammonia), a saving of $30,879. This saving was not entirely due to reduction in dosage of chlorine, but largely to the fact that the plant had not the capacity to treat the flood flows. Thus for 10 per cent of the time the plant was not operated and approximately 37 per cent of the water was not treated. Again, the rain-fall was 10 per cent below normal.

The department has in operation many gas plants, but at this particular point it decided to install a bleach plant. The Board of Water Supply had on hand plenty of lumber, which they had cut from the watershed, and department labor was at hand so that a building could be put up with little expense. Practically all that had to be purchased were bleach tanks and a gasoline pump. There was no money in the appropriations to buy sufficient gas machines to handle the extreme fluctuations of flow, from very low figures up to probably 6,000,000,000 gallons or more per day. Then again, the plant was to be a temporary one. If it is possible to do away with sewage running into the streams, the plant will probably be discontinued.

MR. BRUSH: It should be stated a little more clearly that the plant is simply a temporary plant, since the water goes from there to a gas plant below Kensico reservoir. If it is possible to get rid of sewage the use of the Phoenicia plant will be discontinued, except possibly during the summer season.

STREAM POLLUTION[1]

By Henry B. Ward

It was the author's privilege to spend last summer in studying the problems of stream pollution in New York under the auspices of the Conservation Commission of that state. In connection with the work he found not only a general problem of great interest but particular relations to the work of the various private and public water supply systems that seem of sufficient interest to justify discussing them informally here. The topic of stream pollution presents an aspect of growing importance in connection with the great conservation problems which are being emphasized not only to maintain but to improve upon the position that has been given them in connection with the activities of the war. On this occasion it is proposed to speak on those aspects of water supply work that concern our aquatic resources and their relations to the human species.

New York State has a finely organized Conservation Commission. In its various subdivisions it comes in contact with the natural resources of the state at many angles. From its files abundant evidence has been obtained in the reports of game protectors, of the engineering division, and other bureaus concerning the situation in the state and the changes with reference to stream pollution that have taken place within recent years. The author was able to examine personally the situation on some of the characteristic streams, including both such as were relatively small and also the upper Hudson itself.

There is no doubt that stream pollution has increased enormously within a brief period. From a situation in which it was of significance in very few localities it has increased to the point where it exerts an unfavorable influence upon streams in practically all sections of the state. To be sure, in the forest reserves of the Adirondacks it is even today either an unknown influence or of

[1] Read before the Illinois Section March 27, 1919.

relatively little significance, but generally speaking one could get evidence everywhere in the state that the condition of the waters and of the life in them was being constantly and adversely affected by the addition of trade wastes.

The author's own estimate of the situation bore out the general report. He was born at Troy; as a boy he boated and swam and fished in the waters of the upper Hudson near and above that city. After an absence of some thirty years he went over the same ground during the past year. The changes in the situation were remarkable. Places which in former years had manifested all evidences of relatively pure water, abundant aquatic life and normal biological conditions have been so highly modified by the changes of thirty years that in some places they even look like the banks of an open sewer or the stretches of a septic tank. Not only were the aquatic organisms gone that had formerly been abundant but the conditions of existence had been so radically modified that such organisms could no longer sustain themselves. It was easy to demonstrate the presence of waste materials in the stream. One found in the deposits along the shore and on the bottom, as well as in materials floating in the water, evidence so definite that no chemical examination was required to confirm the findings.

The situation was not unique at this point. It was duplicated at many other places on the Hudson. It recurred with small changes, due to varying factors in the environment, on the Susquehanna near Binghamton and on streams in western New York that empty into Lake Erie. It was possible easily to secure evidence that these conditions had grown rapidly worse within very recent years, and in the opinion of careful observers the situation was directly produced by the introduction of the manufacture of chemicals and the increase in the amount and character of chemical wastes produced in various industries. To be sure the amount of waste uncared for had multiplied abnormally under the pressure of war conditions, for during war times no attention could be paid to the reclamation of wastes or to any other factors save maximum speed in the production of the materials needed for war service. But after all possible allowance had been made for this phase of the situation, it was none the less clear that stream pollution was on the increase and was seriously modifying the biological character of aquatic environments.

In the next place attention is called to the fact that it is impossible to discuss the relation of these things to the water supply and to the work of the members of this Association without commenting specifically upon the classification usually employed with reference to wastes and upon a certain confusion which is introduced into our minds by virtue of this classification. Waste materials are usually designated as domestic wastes and industrial wastes. From the biological standpoint this distinction is fully justified and is of great importance insofar as it is related to real differences. Such differences actually exist and are the basis of the distinction in terminology. The organic wastes of city sewerage systems form a distinct class; they are modified by natural processes too well known to require discussion here and are transformed with well recognized and definitely known rapidity into materials that serve to maintain certain types of organisms in the water. When not excessive in amount they may rightly be said to have a favorable action upon the life in the stream.

Industrial wastes are radically different in character and effect. They are not easily changed by natural processes. They continue unmodified for long periods of time and by movement of the water extend their influence over long distances. Their deposit upon the surfaces of stones and of plants produces a covering that in extreme instances is unmodified by the passage of time in the ordinary sense and that so long as it exists prevents the development of living things. They are thus in the highest degree destructive to normal and desirable conditions.

It must be noted, however, that the distinction between these two types of waste cannot be maintained in practice at the present time. Our cities have not merely increased in size; they have radically modified their character. Even the smallest of them have undergone changes that are apparent on reflection. To the normal wastes of the human population have been added the sweepings and washings of a multitude of manufacturing plants, large and small, all of which turn their materials into the sewers as the easiest method to dispose of them. These waste materials include oils and other chemical wastes of a resistant character that exert upon living organisms in the stream an influence differing only in degree from that exerted by the same sort of materials discharged from great industrial plants. The accumulation of a multitude of such small additions throws a large burden upon the sewerage system and

through it upon the waters into which that system empties. The sewage of Troy is discharged into the Hudson about five miles above the point where Albany gets its drinking water. Years ago natural processes of change made over the materials discharged before even that brief distance was traversed. Today, however, the sewage of Troy is no longer to be regarded as a domestic waste. It contains large amounts of chemicals, if indeed the materials discharged from manufacturing plants and properly classified as industrial wastes do not actually exceed in amount those emanating from the population, which alone are properly classified as domestic wastes. The results on the character of the stream are conspicuous and well known to those who have examined the situation or have read the records of the work done to secure proper drinking water for the city of Albany. The situation at this point is not unique; it could be duplicated at many other places, and water works officials are more familiar than the author with the extent to which municipalities have been compelled to install treatment works in order to secure a proper water supply because of the contamination that the stream has suffered at the hands of communities and industrial plants located higher up.

This is the first of the items to which the author wishes to call attention in discussing the significance of stream pollution for the problems with which water works officials have to deal. It is impracticable and, the author thinks, also unnecessary to discuss the situation in detail from the chemical standpoint. The authorities of many municipalities have experienced difficulties in obtaining and purifying their water supply. In some cases it is one kind of waste and in other cases another with which they have to deal. These difficulties are, and will be for a long time, under detailed discussion in literature and water works officials are more familiar with them than the author could possibly be. His general contention should, however, be clear. The problem of water supply has been made more difficult to solve by virtue of the addition to the normal domestic wastes of large quantities of industrial wastes added indirectly to the stream flow through the medium of city sewerage systems.

Even superficial examination of any large stream like the Hudson River on which are located multitudes of manufacturing plants will serve to show how radically the situation in the stream has been modified in direct fashion by the addition of industrial wastes.

Such materials are poured into it in quantities from various kinds of establishments, by manufacturers of sulphite pulp, by manufacturers of chemicals, by laundries, by gas plants and by multitudes of other industrial concerns that are located along its banks. In the individual cases such a contribution of waste material would exert little or no influence upon the character of the water and the life that it normally contains, but the sum total of these numerous additions is sufficient to wipe out the normal life of the stream and for long stretches the river has been reduced to the level of a stream of polluted water. The mass of material is so great that under existing conditions the stream does not and cannot restore itself and the influence of the industrial wastes may be traced on the banks and bottom bare of living organisms but covered with a slimy and putrid deposit offensive to eye and nose alike. No one industry and no one community is responsible, but the responsibility must be assumed by all and the solution of the problem must be sought in joint and coöperative action.

Such problems concern perhaps most conspicuously the older cities and states of our country. They have not yet made their presence felt in such conspicuous fashion in the newer regions, but it is not too much to say that even in the state of Illinois there are places which give direct evidence of the existence of this problem here and the need for attacking and solving it before it has become more difficult and more extended. Public conferences held in New York State show that public officials in various cities were awake to the importance of the question. Representatives of the State Conservation Committee, of the State Board of Health, of various water companies in the state, of manufacturing industries, and of the commercial fishmen discussed from various angles the difficulties with which each had to contend because of the situation. In that state the Conservation Commission has started a movement to find and apply a remedy. It appears in that instance that the laws of the state, if effectively and impartially enforced, will eliminate much of the evil since those laws provide that industrial waste may not be discharged into any streams in quantity sufficient to interfere with the life or with the reproductive activities of the fish in those waters. In other states the laws may not be adequate and the first step in the situation may be to provide new legislation. It is, however, not too early to examine the situation with a view to determining definitely what must be done in each commonwealth

and prompt action upon the plan decided upon is demanded in the general public interest.

Attention may well be called to the other aspect of the question. There are some ways in which present practices in the field of water supply influence in entirely unexpected manner the character of the stream and its value to the state. One curious instance came to light in connection with the study of a fish epidemic. In a district where the entire watershed was set aside as a reserve and kept for the purpose of furnishing a water supply to a great city the trout in the stream began to die off and perished in large numbers. Evidently some element had been introduced into the situation that was very unfavorable to their existence and might be equally serious for the human species. The cause was not easy to find as the entire region had been kept under most careful control. The commission in charge of the area had apparently so regulated habits and practices as to eliminate all sources of contamination, but after some study the cause was found. Employees were using closed toilets in which powerful chemicals were utilized to treat the waste. These toilets had been emptied into a sink hole a short distance from the stream and with shifting conditions flood water had cut a channel from that depression into the stream itself. With the water came chemicals sufficient in amount to cause the death of the fish. Possibly this insignificant instance does no more than to illustrate the difficulty of controlling absolutely any situation, especially when one has to deal with workmen who are more or less careless and lacking in understanding of the principles which should direct the management of such an undertaking.

The effect of water treatment on the organisms that find their natural habitat in the stream is one on which but little evidence has been collected. The use of chlorine to make city water supplies safe for human consumption is general, but there are on record few if any observations concerning the effect of this treatment on the fauna and flora of the water. A single instance came to my attention in which such treatment was followed by the prompt and total extermination of the minute free living organisms at a distance of several miles at least below the point at which the treatment was undertaken. How far the influence extends, what sort of organisms are affected and to what extent, are questions that need evidently careful consideration. It is important not to lose sight of the fact that serious secondary consequences may follow the introduction of

some treatment that accomplishes the primary result sought for. It is not complete justification of such secondary destruction to maintain that the primary effect was the one desired and that incidental results may be entirely neglected. One may reasonably contend that no method is entirely satisfactory if it achieves a gain at one point by virtue of a loss at another unless the latter is shown to be inseparable from the former no matter what methods of procedure may be followed.

It has been maintained that it would be of advantage to the human species if all of the organisms in our streams could be eliminated since thereby the chance of human infection would be eliminated also. Undoubtedly those who hold such views have in mind really the elimination of such organisms as exert an unfavorable influence upon the water or upon the human species. It seems to the author, however, to be unfortunate that this point of view overlooks entirely other relations of our water bodies. It would certainly be a great loss to the human race from many points of view if all types of life in our streams were totally wiped out. This experiment has actually been tried on a grand scale in western Pennsylvania where the use of streams for washing in the coal mining industry has resulted in imparting to the waters so much sulphur and sulphuric acid that all life in the stream has been entirely wiped out and one may travel for miles without being able to find any of the living organisms which ordinarily frequent such water bodies. In that individual case it is evident that the water has not been improved for human consumption since it has been found impossible to use it in city water supplies.

It is true, to be sure, that water courses follow natural channels, and that whatever liquid waste is produced must sooner or later find its way into those channels and follow them down hill. We cannot hope to make water run up hill successfully under any other than very limited conditions, but this is by no means a justification for turning loose all sorts of liquid wastes to find their way into the streams, whatever be the effect upon those streams. In the author's opinion, the principle at issue can be well illustrated by comparing the waterways to the roadways of the country. Very likely there are some persons in the audience who can recall the period at which any convenient roadside was regarded as an entirely proper place to deposit refuse and when piles of waste material in different stages of disintegration might be found in many places,

even in our cities. In fact, it was long considered good form, in certain social circles and certain districts at least, to pitch all sorts of waste matter over the fence into a vacant lot or to pile it in the back alley if not in the front street. The practice of garbage disposal after this fashion was all too general at one time among a large part of the population. Today no one would think of justifying such a procedure, and whether it be in one portion of the city or another, every well regulated municipality would visit a heavy penalty upon the citizen that indulged in such habits of disposing of his waste. At the present day our streams stand exactly in the place where our streets were fifty years ago. The public regards them as a convenient and proper place for the dumping of refuse. Waste thrown into a stream is ordinarily carried on well below the point where it is deposited and usually so thoroughly removed as to leave no evidence at the point where it started. Furthermore, it carries with it no marks which enable the finder to determine the place of its origin. It is well known that both state and national governments have had to deal with various communities and regions because the practice of dumping refuse in streams had been carried to the point where it was seriously interfering with the navigation of the stream, so that in general local or state regulations provide today that refuse may not be dumped from city docks into navigable streams. However, the practice has not been abandoned and some times assumes serious proportions, as may be witnessed in many places in connection especially with the smaller streams of the region in which this meeting is held. It is essential to develop public sentiment against this abuse and this can be done only by educating the people to appreciate the need for keeping the streams as clean and free from waste and refuse of all sorts as the streets of our well kept cities.

The attitude of the individual citizen is but a copy on a small scale of the attitude of the large industry. The solution of the problems of stream pollution will never be found until men and corporations are led to see that their own legitimate rights do not include the privilege of trespassing upon the rights of others. It may be expensive for the citizen to provide that his garbage is disposed of in proper fashion, but the community decrees that he shall assume that expense and penalizes him if he fails to heed the regulations controlling the matter. In the same way it may be costly for business to care for waste chemical substances that are

produced in the course of its manufacturing procedure, but this expense must equally be regarded as a part of the natural and inevitable cost of the business. It is not just to saddle it in whole or in part on the community to its disadvantage or to pass it on to the disadvantage of those living below on the banks of the stream or seeking to use the water as a basis for individual or community water supply. Provisions must be made to compel each individual and each interest to care for its own responsibilities and to pass on the water of the stream to those lower down in as good condition as it was received from the region higher up.

One factor which has served to draw attention to the question has grown out of the manufacturing industry itself. The plant located downstream has ascertained that the water is not desirable for its purposes because of the addition of wastes from some manufacturing plant higher up on the water course, and the man lower down has sought to establish his right to secure as good a supply of water as that which came to his neighbor higher up. Individual water companies and communities, both small and large, have noted the deterioration in the quality of their water by virtue of the changes wrought in the streams through the addition of manufacturing wastes in the enormous quantities in which they are contributed by some of our great present day industrial plants. The insignificant evil of yesterday has grown so large it is unbearable today. The only real solution of the difficulty lies in the maintenance of natural conditions. When all classes of people are interested in our streams from different points of view, when they coöperate in introducing, passing and enforcing proper regulations to grant equal rights and privileges to all and on the other hand to demand equal consideration from all, then it will be possible to remedy the present situation. However far in the future this ultimate solution of the question may lie, it is imperative that some steps be taken now throughout our country to stop the rapidly increasing pollution, to limit the destruction of the natural aquatic resources and to preserve from further deterioration the present water supply. To this must be added as rapidly as possible another but related movement for the total elimination of those evils which have grown up in the past. Conditions must not be allowed to grow worse at any point and must be improved as rapidly as possible.

A SUGGESTION IN REGARD TO STATE CONTROL IN THE DESIGN OF SMALL WATER WORKS[1]

By Frederic Bass

Among the states where the health departments have developed strong departments of engineering or sanitation to carry out comprehensive laws governing the quality of public water supplies there has resulted, without doubt, a very distinct benefit to the public health. Many an epidemic which otherwise would have exacted a toll of suffering and death, has never had a chance to start. Engineers designing works have generally submitted their plans to the State Board of Health for standardization, so that they shall meet all of those requirements of design which have been found necessary and desirable for assuring to the public that a reliably safe water for domestic purposes shall be provided.

It is possible to trace a direct relation between such preventive measures and the death rate in the community concerned in many cases, and it might be possible to demonstrate the value of the sanitary supervision of water supplies to insurance companies, but no life insurance company has as yet been, so far as the author knows, an active agent in systematically encouraging the public to adopt preventive measures of this character.

When the engineer views the water works problem from the standpoint of a device for preventing the beginning and spread of fire he sees an entirely different attitude both on the part of the state and of the insurance interests. In this case the companies are awake, whereas the state is asleep, directly the opposite condition seen in sanitary control. In neither case are the two most interested parties working together.

The benefits of state sanitation have been demonstrated in raising the standard of quality of water supplies and it is fair to assume that state control of municipal fire-prevention measures would be equally valuable provided the work were done in the scientific manner that

[1] Read before the Minnesota Section.

sanitary control has been done. It might be argued that the fire departments, water works, building inspection and other factors involved in fire prevention be turned over to the fire insurance companies, so that unity of control might be accomplished and efficient protection secured, but so many political difficulties are obvious in such a plan that it does not appear feasible. Another plan more promising, which would meet the requirements of the case, would center in the state governments the responsibility for fixing standards of fire protection in cities, and among these the most important single item would be that of water supplies. A board which could control the entire design of public water supplies, and inspection of operation as well, would be desirable, in the author's opinion. The sanitary features are so well understood by sanitary engineers, bacteriologists and sanitary chemists, and there is so little of human physiology of character requiring a medical man, that in the event of general state control of water works, the board exercising it might well relieve the State Boards of Health of its control of water supply. On the other hand, the sanitary control might be left as it is, in the hands of the Board of Health, and the fire protection control be provided separately, in which case there should be some provision for unfailing coöperation between the two boards.

In England there has been for many years, a Local Government Board which advises municipalities in regard to financial problems, public health and housing problems, constructional problems and others, and in addition exercises considerable control over all, inasmuch as, subject to special Parliamentary Acts, it governs capital issues, in much the same way as did the Capital Issues Committee of the United States during the war.

An investigation into the feasibility of securing higher standards of design, construction and operation of public water supplies, whether by state control or otherwise, not only in regard to sanitary requirements, but in regard to economy and fire protection is worthy of the study of the American Water Works Association.

COST OF EMERGENCY PUMPING AT GRINNELL, IOWA[1]

By William G. Raymond

The city of Grinnell, Iowa, has a municipal water plant consisting of certain deep wells, cisterns into which the water is pumped from these wells, and a standpipe and distribution system. Formerly the city owned and operated its own pumping plant but in the early part of 1916 it entered into a contract with the Iowa Light, Heat, & Power Company, a company supplying electric light and power and steam heat in the city of Grinnell, to take over the city's pumping operations. The power plant adjoins the site of the wells and standpipe.

The pumping done by the city had been by means of an air lift from the wells into cisterns and with pressure pumps into the distribution system. The power company, on taking over the contract, believing from representations made to it by a deep-well concern that it could operate with greater efficiency by the use of motor-driven deep-well pumps for lifting the water from the wells into the cistern than it could by operating the air compressors, installed two deep-well pumps in the two wells of the city and began operations.

The contract price for pumping was 9½ cents a thousand gallons, the water being measured by the city's meter on the main at the beginning of the distribution system.

The deep-well pumps were installed in the fall of 1916 and continued in operation until early in 1918, when one of the wells got out of repair, rendering pumping from it impossible. The remaining pump was unequal to supplying the demand from the one well, and at the suggestion of the city the company installed one of the city's old air compressors in its plant and undertook to lift water from the one remaining well by the air-lift method. It was successful in doing this and was able to furnish an adequate supply, but it complained that the cost of pumping was much increased and asked the city for relief, and an understanding was entered into that

[1] Read before the annual meeting of the Iowa Section on April 17, 1919.

pending the sinking of another well and the return to normal conditions of pumping, the city would pay the actual cost of pumping.

Thereafter, following March, 1918, the company billed to the city monthly what it determined to be its several items of cost. As a result of an experiment made with one of the air compressors hooked up to be driven by a motor, the company estimated that 6 kilowatt-hours were required to lift 1000 gallons of water from the well nto the cistern. As a result of a report by the Krehbiel Company, the power was estimated to cost varying sums, depending on the cost of coal, ranging from 2.9 to 3 cents. The company had installed a triplex power pump, motor driven, for forcing water from the cisterns into the mains, and the motor driving this pump was metered so that the quantity of power was known. In addition to the cost of power for lifting the water from the wells and forcing it into the mains, certain charges for oil and labor used exclusively in connection with the pumping were made; and as a result of all these charges, including depreciation on the unused pumping plant, the pumping was billed during the following months at costs which made the cost per thousand gallons vary approximately from 22 to 24 cents.

The Iowa Light, Heat & Power Company, in the fall of 1918 appealed to the Iowa State Board of Conciliation for higher rates for electric service in the city of Grinnell and for adjudication of the water pumping costs which had been objected to by the city as too high. The city and the company both appeared before the Board of Conciliation at a hearing in October, and both parties to the controversy seemed inclined to do the fair thing if that could be discovered. The city, however, had very few data to present tending in any way to disprove the claims made by the company and the Board of Conciliation, after granting a certain small increase in rates for lighting and power, felt compelled to recommend a cost of 22 cents per thousand gallons for pumping in spite of the fact that this appeared to be an exorbitant price. At the same time it informally recommended to the city that a more careful investigation be made of the actual cost, as it appeared to all the members of the Board that some discrepancy must have crept in to affect the results of the experiment made by the power company to determine cost.

Accordingly, the city of Grinnell engaged the author to make an investigation of the cost of pumping, which he did in January, 1919, the

actual measurements in the test being made under the direction of and by Professor George J. Keller, acting head of the Department of Mechanical Engineering in the State University of Iowa. As the rate was to be temporary pending the putting into use of the new well, it was thought to be undesirable to go to the expense of making a complete valuation of that part of the company's property which was in any way concerned with the pumping operations, and as the plant is practically new, the company's statement of costs of plant and equipment was used for estimating interest and depreciation charges. The books of the company were examined to discover the cost of labor, fuel, and supplies, and the meter readings of the meter through which the company buys its water for steam making were taken as indicating the quantity of steam produced. Of course there is a slight error here, but it is insignificant and it was thought that the readings extending over a year would be of more value than the results of a single test which would be costly to make.

It was thought that the great discrepancy, if any, lay in the determination of the amount of power used in lifting the water by the air lift from the well into the cistern. The method of test here was to measure the steam flow to the compressor by means of a flow meter and to measure the water pumped into the cistern during the period of steam measurement. This required the shutting down of the power pumps during this same period and the calibration of the cisterns. As a result of this test it was found that the compressor used not to exceed 3040 pounds of steam per hour and that this quantity of steam used resulted in the lifting of 12,210 gallons of water or approximately 249 pounds of steam per 1000 gallons of water. It remained, then, to find the cost of the steam, to which would be added the cost of such labor and supplies as pertained exclusively to the pumping system, and the cost of the power pumping.

As the figures for quantity of water pumped, coal consumed, etc., were given in the records by the month and as the period of operation during 1918 was nine months, the amount of steam consumed had to be determined by estimating the number of gallons pumped during the nine months; and this could be done only by using the meter records of the city's meter at the beginning of the distribution system. It was claimed by the company, and, after a test, admitted by the city, that this meter had run slow by varying amounts, which for the purpose of the computation it was agreed had averaged about 15 per cent, so that the sum of the meter readings was assumed to

indicate 85 per cent of the water pumped. Using the 249 pounds of steam per thousand gallons lifted and the correct amount of water pumped during the nine months, the consumption of steam for the whole period by the air compressor was obtained. The remainder of the steam generated was charged to power production as one of the elements in obtaining the cost per kilowatt-hour of generating power. The details of this process need not be given but it may be mentioned that interest at 6 per cent on all of that part of the plant concerned with steam making was allowed in determining the cost of steam, and 6 per cent on the cost of the entire plant was allowed in estimating the cost of generating power. Depreciation also was estimated on the depreciable parts of the property by the compound interest method at the 6 per cent rate, as it was understood that the company carries a depreciation reserve. The net profits from steam heating as stated by the company were used as profits arising from a by-product reducing the cost of steam and power. As a result of the entire computation the following was found:

The cost for power was $0.02977 per kilowatt-hour.

The amount of power used for power pumping was 0.46 kilowatt-hour per 1000 gallons, giving the cost of power pumping for power alone $0.01369 per 1000 gallons.

Interest and depreciation and plant labor and supplies, chargeable directly and only to pumping operations amount to $0.02760 per 1000 gallons.

The air pumping, exclusive of the interest and depreciation, plant labor and supplies, chargeable only to pumping operations, appeared to be as follows:

	per 1000 gallons
Fuel	$0.084949
Labor	$0.01377
Water	$0.00239
Station maintenance	$0.00896
Interest and depreciation	$0.01405
Total	$0.12411
Credit for steam heating	$0.01013
Balance	$0.11398

Against the total cost, an allowance of 0.3 cent was made on account of accrued depreciation, and the total cost per thousand gallons for pumping was thus found to be:

	per 1000 gallons
Steam for air pumping	$0.11398
Power for power pumping	$0.01369
Special labor, supplies, interest and depreciation	$0.02760
Total	$0.15537
Less for depreciated plant	$0.00300
Net total cost of pumping	$0.15237

Settlement was made by the city on this basis.

The well referred to in the foregoing is about 2000 feet deep, cased with 7-inch pipe for 320 feet and with 5-inch pipe to a depth of about 1460 feet, below which the well is in limestone and sandstone. The air lift is of the simplest type, a $1\frac{1}{2}$-inch air pipe extending down 650 feet into the well, the water standing at 260 feet below the surface when there is no pumping. It is not known how much it is drawn down during pumping.

The air compressor was an old simple steam, compound air Ingersoll, with poor valve settings at the time the test was made, with 12 by 12 inch steam cylinders and 10 by $16\frac{3}{4}$-inch air cylinders, developing 71.6 horse-power. The efficiency of the entire machine was $83\frac{1}{2}$ per cent. The air pressure developed was 145 pounds when running and 165 pounds at starting.

Coal cost almost exactly $4.00 a net ton in the yard. The total pumpage was slightly in excess of 7,000,000 gallons a month or about 235,000 gallons daily. The normal pressure of the distribution system at the plant was 40 pounds, with an increase for fire pressure.

The city saves something like $5000 a year as the result of the more careful determination.

WATER WORKS IMPROVEMENTS AND FIRE INSURANCE RATES[1]

By Kelsey L. Walling

The word "improvements" implies a condition in which perfection in the water works department has not been attained, and as each city has its own independent problems, we can only speak in generalities of desirable conditions.

The classification of a city for the purpose of insurance rating is dependent upon the efficiency not only of the water works but also the fire department, condition of the streets, the general character and construction of buildings, and the enforcement of proper ordinances. With a very few exceptions, the towns and cities of Iowa were classified under the rules of the Western Union Schedule, which has been applied generally in the middle and western states. Recently the Standard Grading Schedule of the National Board of Fire Underwriters has been adopted, but as yet it has been applied in only a few instances. This schedule, which brings practically the same results as the former treatment, although more technical in its application, is more susceptible to easy analysis in many of the details. Further reference will be made to this schedule later on.

The requirements for water works protection may be briefly outlined as follows:

Source. To be unfailing. If unreliable, a storage basin should be provided.

System. First, Gravity System. Supply from an unfailing source with impounding capacity of at least 30 days average domestic consumption.

Second, Combined System. The combined capacity of a reservoir or standpipe and pumps to be 100 per cent greater than the total of the maximum daily consumption and the estimated fire flow.

Third, Direct Pumping System. Pumping capacity to be 100 per cent greater than the total of the maximum daily domestic consumption and the estimated fire flow.

[1] Read April 17, 1919, at the Annual Meeting of the Iowa Section.

Boilers. To be equal in capacity to that of the pumps. Boiler feed pumps, injectors and steam pipes to pumps to be in duplicate.

Pump house. To be of fire-resistive construction and secure from inundation. Station to be equipped with a recording water pressure gauge.

Filtering plant. If any, to have a capacity equal to the maximum daily domestic consumption and estimated fire flow unless pumps have direct connection to source of supply or unless the clear water basin has a capacity of at least one day's maximum domestic consumption.

Pressure. Pressure at pumping station or elevation of reservoir or height of standpipe should be sufficient to force the required fire flow over the highest buildings, uuless fire department is provided with steamers.

Fire flow. The estimated required fire flow ranges in accordance with the population, from 1000 gallons per minute for a population of 1000 inhabitants to about 9000 gallons per minute for 70,000 or 75,000 population. These figures are furnished by a table and are approximate only, the definite amounts to be determined upon inspection, considering the compactness and height of the buildings and values to be protected.

Mains. Main arteries should be ample in size to carry with moderate frictional loss, the domestic and fire consumption, and should be in duplicate. Mains in the business center and congested manufacturing district should not be less than 10 inches in diameter with 8-inch cross-connecting mains, and in the residential section, not less than 8 inches in diameter with 6-inch cross-connecting mains. Sufficient large feeders should be provided for all sections of the town to insure suitable circulation, and all systems should be free from dead-ends. No smaller mains than 6 inches in diameter are recommended.

Gate valves. Gate valves are to be located at points so that it will not be necessary to shut off service more than the length of one block in the congested districts or more than two blocks in the residential districts. All branch connections to hydrants should be provided with gate valves.

Hydrants. To be "staggered" and should be located from 150 to 300 feet apart in the mercantile and manufacturing district, and from 300 to 600 feet apart in the residential district. Hydrants should have no less than 2½-inch outlet and a steamer connection

where steamer service is available. Street connections and riser for hydrant should not be less than 6 inches in diameter. Hydrants and threads on outlets to conform with the National Standard.

High pressure system. Water works system to be augmented by a separate system of high pressure pumps and mains to be utilized at times of fire and to carry sufficient pressure for direct fire fighting.

Records. Daily statement of consumption and pressure should be made and complete records of pipe, valves, hydrants, etc., to be kept in fireproof vault.

This, in brief, is an outline of the standard requirements for a first-class city insofar as the water works department is concerned. The gradings for second, third and fourth class cities are for the most part percentages of the requirements for the first class protection. Therefore, any improvements tending to increase the capacities of pumps, pipes, boilers, etc., so as to meet the domestic consumption plus the fire flow will result in better grading of the protection afforded by the water works department.

Of the cities of Iowa, Davenport leads with a second-class grading. Several cities have been graded as third class, while the majority of the water works towns, as is also the case in most states, are fourth class.

In a city of the third class, the *Source* of water supply should be standard, or unfailing; the *System* at least 50 per cent of standard; *Pump House*, substantial brick construction, unexposed; *Boilers*, standard, except that duplicate steam pipes to pump are not necessary; *Filtering Plant*, if any, 50 per cent of standard; *Pressure* and *Fire Flow*, standard; *Mains*, in business and manufacturing district not less than 8 inch, with 6-inch cross-connecting mains, and should have sufficiently large feeders to supply suitable circulation for domestic consumption and fire flow, but it is not necessary to have force mains in duplicate. From this it will be seen that any city having properly fulfilled the requirements for third class may secure a better grading by providing duplicate force mains and boilers and pumps for reserve purposes, which will increase the reliability of the system. The system in a third class town merely meets the conditions of domestic consumption and fire flow. Less than that would be three and one-half, or fourth class, while better would be two and one-half or better, according to the percentage of pumping capacity, boilers and mains in reserve.

We now come to the relation between water works improvements and fire insurance rates. As the water works is only one department considered in the classification of towns or cities it must be treated in conjunction with the fire department, public fire alarm system, Building and General Ordinances and streets.

For the purpose of comparison, a one-story brick building in a fourth class town takes a basis rate of 39 cents, in a third class town 35 cents, and in a second class town 31 cents.

A one-story frame building in a fourth class town takes a basis rate of 77 cents, in a third class town 71 cents, and in a second class town 67 cents.

The difference in the basis rates between the several classes will figure 13 per cent on brick or fireproof buildings and 8 per cent on frame buildings.

The Standard Grading Schedule of the National Board of Fire Underwriters is based upon the plan of an assumed number of points of variance from established standards. The total points of deficiency is 5000, allotted in accordance with their relative values as follows:

Relative values

		Points
Water supply	Engine stream basis	1700
	Hose stream basis 2000	
Fire department	Engine stream basis	1500
	Hose stream basis 1200	
Fire alarm		550
Police		50
Building laws		200
Hazards		300
Structural conditions		700
Total		5000

The deficiencies chargeable to the water works may not exceed 1700 points. These charges are made on the conditions of variance from standards which by experience and calculation are considered necessary for the character and congestion of the buildings, areas of built up section, and population.

These points of deficiency are sub-divided under the following headings which will be referred to briefly and without analysis.

1. Appointment. Employees on municipal systems to be under civil service rules with tenure of office secure.

2. *Chief executive.* To be competent and qualified by experience.

3. *Records or plans.* Records and plans of the physical structure and system to be complete, safely filed, in duplicate, indexed and up-to-date.

4. *Emergency crews.* To be on duty at all times or quickly available. An emergency wagon with necessary tools to be provided. At least one employee familiar with the system should respond to fire alarms in mercantile districts and second alarms elsewhere.

5. *Alarms.* To be installed in department quarters, in pumping stations and where pressures are raised for hydrant streams, duplicate alarm circuits as to stations.

6. *Adequacy.* As regards capacity of source and supply works to deliver required supply. In calculating the deficiency under this item results obtained under fire flow tests in most favorable location are used. Ten hours fire flow in addition to the maximum domestic consumption is desirable in towns of over 2500 population.

7. *Reliability of source of supply.* As may be affected by forest fires, floods, ice dams, shifting of channels, condition of intakes.

8. *Reliability of pumping capacity.* On which supply is dependent.

9. *Boiler capacity.*

10. *Condition and arrangement and reliability of plant equipment.*

11. *Fuel, and accessories for the transmission of power.*

12. *Pumping stations.*

13. *Reliability and installation of supply mains.*

14. *Arterial system and minor distributors and gridiron system.*

15. *Gate valves,* as to location, inspection and condition.

16. *Hydrant distribution,* size, installation, and condition.

It is not the purpose of this paper, nor is it feasible in so brief a time, to enter into all the details of water works engineering, but the author has endeavored to show that improvements which will raise a city one full grade of protection will result in a reduction of 8 and 13 per cent in the basis rates on frame and brick buildings respectively.

FUTURE PUBLIC WATER SUPPLIES IN IOWA[1]

By Lafayette Higgins

The following discussion on the future public water supplies of Iowa is intended to be descriptive rather than technical.

Until comparatively recent times, to speak of a public water supply for any inland location was to call to mind the supply obtained from wells. Occasionally such a supply has been furnished by springs. If any such inland territory was developed bringing the land or soil into active cultivation, the natural water supply due to the rainfall and collected mainly in shallow wells, became less and less, until in many instances such sources of supply were abandoned. Following natural inclination, deeper wells came into use and as these failed to supply the need still deeper wells were constructed.

With the better development of cities and towns, the more complete sewering and the more extensive improvement of streets and parks, the constantly increasing use of the public water supplies taxed heavily the resources of the wells, rendering such sources of supply inadequate and unsatisfactory. The lack or the failure of a public water supply by means of wells led to the use of lake and river waters where such were available; and in localities where well supplies are neither available nor suitable and lake and river supplies are impracticable by reason of distance, impounding reservoirs constitute the only remaining available source of supply.

Water is sometimes spoken of as a universal solvent for the reason that most substances readily dissolve in water and very few substances entirely resist solution. This means that any considerable part of rainfall which percolates through soil is continually picking up soluble substances contained in the soil. Therefore any water which sinks to any great depth through earth strata will contain in greater or lesser degree, a considerable mineral content, thereby rendering such water unsuited to some extent for ordinary purposes and sometimes rendering such water totally unfit for either domestic or industrial uses.

[1] Read before the annual meeting of the Iowa Section, April 16, 1919.

The history of deep wells in Iowa may be understood and it is perhaps unnecessary in this discussion to include much of the life history of such wells.

What may be considered deep wells in Iowa, ranging from 200 to 2400 feet in depth, may contain a mineral content ranging from 800 parts to 3000 parts per million. Many of these wells furnish a clear, sparkling water, suitable for drinking purposes, and possibly suitable for other domestic uses at a costly outlay for treatment to partially remove the mineral content usually spoken of as hardness. In the majority of instances, however, the deep well water of Iowa contains mineral compounds rendering the water unfit for ordinary domestic and industrial uses.

It appears to be a working rule among eastern water works engineers that it is ordinarily useless to attempt to render water containing more than about 1100 parts per million of mineral content satisfactory for domestic use by any of the methods of treatment now employed to reduce hardness. Since this discussion is not intended to be technical the reasons for these conclusions may be omitted, with the single statement that it has ordinarily been found that if water contains more than about 1100 parts per million of mineral content, the treatment of the water to remove hardness in large measure simply transposes the so-called hardening and encrusting constituents into other mineral compounds which, though considered soft or non-encrusting compounds, render the water unfit for both domestic and industrial purposes.

With the history of deep wells now abandoned because of this latter condition, we have little concern. As a general proposition, however, the deep well is a costly and unsatisfactory source of public water supply; costly in installation, costly in maintenance and costly in the treatment necessary to adapt it either to domestic or industrial uses. At the present time the deep wells which may be considered to any considerable degree successful and which seem fairly satisfactory to the users, may be found in what might be termed the northeastern one-third of the state. In this portion of the state are found several flowing wells, which in times past have been favorably considered, which generally furnish a highly mineralized water which is considered more and more unfit for use as the years go by. Deep wells installed in middle, south and southwest Iowa have either been abandoned or will be abandoned in the near future.

Another portion of the state of Iowa, which might be roughly described as the northwestern one-third, generally makes use of shallow wells, rarely reaching a depth of 400 feet. The mineral content of these wells is sometimes surprisingly heavy when the depth of the well is considered. In a very few instances in this northwest territory deep wells have been located and occasionally these deep wells are flowing wells.

The increasing draft upon the public water supply of a city or town, occasioned by the installation of a sewer system and the increasing use of such sewer system, usually soon renders inadequate the deep well supply which at first had been found sufficient. The exhaustion of any deep well supply may be considered purely a question of time. The geologists may speculate and compute the possible period of time required for the percolation of rainfall to reach the deep lying strata which furnish the supply for the deep wells, but the reasonable conclusion of the problem is that any considerable daily draft upon such a supply, when continued indefinitely, will curtail and possibly exhaust it. Quite a number of our cities have experienced such results, and have realized the futility of attempting to perpetuate a satisfactory supply from such sources.

On the other hand, many of our inland towns and small cities, particularly in the northern and northwestern portion of the state, have been using wells of moderate depth and capacity. Some of these wells from 200 to 400 feet deep will yield 7000 gallons of water per day; others may yield 25,000 to 35,000 gallons per day and occasionally one is found which may be rated at 100,000 gallons per day. It is easy to see that a town of 1000 population using 60 gallons per capita, which should be a minimum rating when sewer systems and other improvements are installed, does not have a very promising chance for an adequate water supply. Conceding that in such localities such wells must be depended upon as a source of public water supply, the only apparent remedy for the failing supply is to install more wells until the sum of the output is sufficient for the necessary supply.

However, in southern and southwestern Iowa, very little water supply may be obtained from shallow wells and as a rule the supply obtained from deep wells has been found inadequate or unsatisfactory. There remains for these portions of the state little opportunity for a satisfactory source of water supply, except to

make use of the water of the streams through proper purification or by making use of impounding reservoirs located in suitable catchment areas.

This brings us to the consideration of what appears to the author as the probable future practice throughout the state of Iowa.

First. In the inland portions of the state where lakes and streams are not available and where impounding is practically impossible, the municipalities must still make use of drilled wells or tubular wells, multiplying the number of wells to obtain an adequate supply and treating the water of such wells where possible to remove excessive hardness or excessive iron content.

Second. In any locality where an unfailing, natural stream of water of any considerable flow exists, the future public water supply of municipalities located in reach of such a stream may be satisfactorily solved by making use of its water. It may be that the valley of such stream contains gravel beds sufficiently free from silt to permit the collection of the water supply by driven wells, tubular wells, dug wells, or by the gallery system. It is a discouraging fact, however, that very few of the gravel beds lying in our river valleys or adjacent to the streams are suited to the collection of water by means of driven wells. A somewhat larger number will afford the supply by means of tubular wells. However, not many of such locations permit extensive collection of water by means of dug wells and there is only an occasional location where the gallery system can prove permanently effective.

Instances of the failure of driven wells are numerous, although a number of our municipalities are still depending upon this method of collection, preferring to keep up a continual cleaning and replacement of wells rather than to resort to more modern methods. Instances of apparently successful collection by means of shallow tubular wells are not infrequent. Perhaps the largest inland supply furnished by such means of collection is at Newton, Iowa, where tubular wells from 6 inches to 8 inches in diameter and about 50 feet in depth, located in the valley of the Skunk River, about 6 miles from the city of Newton, furnish an apparently inexhaustible supply of excellent water. In this particular instance it would appear to be only a question of multiplying the number of wells and increasing the supply main leading to the city in order to furnish an unlimited supply for the use of the city of Newton, no matter how large the city may become in the future.

The city of Des Moines appears to furnish the one notable instance of successful gallery collection in this middle west country.[2] It is understood that only a few public water supplies of the United States can be as successfully operated by the gallery system.

However, where it is possible to collect a water suppy economically from a river valley by these methods, the supply should be so collected and the water given whatever treatment may be necessary to make it safe and suitable for domestic use. Such treatment may consist of nothing more than chlorination to eliminate pathogenic germs; but it may include, and must necessarily in some locations include, the removal of the iron content which is almost always present in such waters, and it may also require some treatment to reduce the hardness.

Where it is not possible to collect economically the public water supply of a river valley by means of the foregoing methods, the final chance is the use of the water of the river itself. It is, of course, understood in such a case that modern methods of purification and filtration will be employed, but the efficiency of such methods is long past the experimental stage and is now recognized as an accomplished fact.

Recent instances of the necessity for such use of stream water are the city of Clarinda, which in times past has depended upon shallow tubular wells and now contemplates taking the stream water and purifying the same by means of a mechanical filter plant, and the city of Fort Dodge, which is now contemplating a supply taken directly from the Des Moines River and likewise purifying it by means of a mechanical filter plant.

The future record of the public water supplies in Iowa will include many such instances of abandonment of the present methods of collection of public water supply and the institution of direct river supplies. It is likewise true that municipalities which have not yet installed an adequate public water supply will prefer to attempt a river supply rather than to engage in the costly and unsatisfactory experimentation of a tubular well supply.

Third. In any locality where neither shallow nor deep wells are successful and where an adequate river or lake supply is wanting, apparently the only source of public water supply will be the catchment area and the impounding reservoir. This proposition demands

[2] See JOURNAL, September, 1919, p. 475.

at once a consideration of the rainfall and the run-off, the topography, the character of the soil and the surface pollution.

It is common to place the annual precipitation in the state of Iowa at approximately 30 inches. A closer examination of data reveals that the annual precipitation in the northwestern corner of the state is 25 inches, and in the southeastern corner between 35 and 40 inches.

Lines of equal precipitation plotted upon the map would show the 25-inch line running through the center of Lyon County near Rock Rapids and extending in a northeasterly and southwesterly direction. The 30-inch line enters the state at Council Bluffs in Pottawattamie County, runs northeasterly to Rockwell City, thence to Fort Dodge, thence to Waverly, thence in a more northeasterly direction to Decorah and crosses the state line within, and near the northwestern corner of, Allamakee County. The 35-inch line enters the state in Ringgold County, thence runs northeasterly to Leon, Eldon, Fairfield, Washington, Tipton, and crosses the state line and the Mississippi River at Dubuque, thence running almost due east in the state of Illinois. The 40-inch line is entirely south and east of the boundaries of the state. The foregoing review of the annual precipitation will indicate that those localities of the state where impounding must be employed are, generally speaking, the portions of the state where the heaviest rainfall occurs.

A study of the topography of the state and the rainfall determines that in certain portions of the state perhaps 75 per cent of the rainfall enters the soil and 25 per cent becomes run-off, while in other portions of the state perhaps not more than 25 per cent of the rainfall enters the soil and 75 per cent of the rainfall is run-off.

Ordinarily in localities where impounding must be employed, the run-off is more than 50 per cent of the rainfall. Barring dry periods and years of scant precipitation, the topography of the state and the character of the soil in these localities are favorable for the use of catchment areas and impounding reservoirs.

Instances of the successful collection of public water supplies by such method are Centerville and Chariton, both of which cities exhausted all possibility of obtaining public water supplies by means of deep wells and have now succeeded in obtaining satisfactory supplies by the method of impounding and treating the water. A number of other municipalities in southern Iowa have adopted this plan more or less successfully, and it is evident that in southern

Iowa the future public water supplies will be largely impounded where streams are not available.

It is not the purpose of this discussion to enter into a technical explanation of the collection of impounded supplies, the care of impounding reservoirs or the treatment of the water. While it is necessary to exercise all possible sanitary precautions in the selection and care of catchment areas, and it is necessary to protect the impounding reservoir, and sometimes necessary to treat the water of the reservoir to abate algae and plankton, and also necessary to give the impounded water proper treatment to clarify and disinfect it, all of these precautions may be employed and all necessary treatment may be supplied under the knowledge now at hand and by methods now employed.

It is understood that primarily the rainfall furnishes our water supplies no matter what the method of collection. It is true, however, that our attention is directed to the question of rainfall more anxiously in the case of impounded supplies because such supplies are almost wholly made up of run-off water.

A few mistakes have been made locally in estimating the required area of watershed. In certain localities it may not be wise to consider that more than 6 inches of the annual rainfall may be available after allowing for rapid run-off, evaporation and percolation. In other localities the effective amount may be 8 inches or more. By computation of the volume of supply based upon utilized rainfall, the necessary area of watershed may be determined. An effective recovery of 6 inches of rainfall per square mile would provide for a daily supply of approximately 300,000 gallons.

We may therefore summarize the probable future practice in locating and installing future public water supplies as follows:

1. Supplies from rivers and lakes.
2. Supplies from catchment areas and impounding reservoirs where streams and lakes are not available.
3. Supplies from wells in localities where streams and lakes and catchment areas are not available.

Finally the tremendous part which water plays in the natural world and in the sustenance of human life, demands such water supply at whatever cost. It is also true that water supplied at any cost is still the cheapest of the necessities of life. It would appear to be possible to collect and purify the stream and lake water and the impounded water of the state at a cost not exceeding $25.00 per

million gallons, except during flood times or times when silt and surface pollution are maximum. This would mean a cost of 2½ cents per 1000 gallons; and under abnormal prices we might estimate the cost of the collection and purification at 5 cents per 1000 gallons. It would appear, therefore, that the actual cost of collection and purification is one of the minor costs of a safe, sanitary and satisfactory public water supply.

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